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Effects of feeding Ractopamine (Paylean) on growth and carcass traits in finishing pigs marketed at equal weights

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Four hundred seventy-two pigs were used to determine the impact of feeding ractopamine hydrochloride (RAC) in an equal ending weight marketing scenario. The study was carried out as a randomized complete block design in a 2×3 factorial arrangement. Barrows and gilts were fed 3 different RAC concentrations before harvest (0 mg/kg, 5 mg/kg for up to 35 d, or 5 mg/kg for 21 d followed by a step-up to 7.4 mg/kg for 14 d). Pigs were allotted to single gender pens at 34.5 kg initial bodyweight (BW). Pens (48) were allotted to treatment when the population mean BW reached 97.3 kg, then variation of bodyweight within each pen was accounted for. Pigs were individually weighed on a weekly basis. Each week, all pigs reaching or exceeding 124.4 kg were individually tattooed and tracked through the commercial processing facility. Each treatment was represented during each harvest period. All remaining pigs were marketed on d 35 of the feeding trial. Individual hot carcass weight, loin depth and backfat depth data were collected on all pigs (n = 457; 13 lost during harvest). Individual pig data were then averaged across the pen, which served as the experimental unit. Ractopamine treatments were pooled for analysis, because no treatment differences ($P > 0.05$) were found between the 5 mg/kg for up to 35 d and 5 mg/kg to 7.4 mg/kg step-up program. There were no interactions ($P > 0.05$) between sex and diet, therefore only main effects are reported. The coefficient of variation (CV) in beginning BW of RAC (7.16%) and control pigs (6.95%) was not different ($P = 0.68$). However, RAC fed pigs (3.91%) had lower ($P < 0.01$) market BW CV than controls (5.27%). Pigs fed RAC reached market weight 2.48 d earlier ($P = 0.01$) than control pigs. Ractopamine fed pigs had an improved ($P < 0.01$) feed efficiency and a greater ($P < 0.01$) ADG than control pigs. Control and RAC pigs did not differ ($P = 0.18$) in ADFI. Ractopamine fed pigs also had 3% greater HCW ($P < 0.01$) and a 3% increased loin depth (LD) ($P = 0.05$). Ractopamine fed pigs had 1% improved dressing percentage ($P < 0.01$) than control pigs. However, fat depth (FD) was not different ($P = 0.40$) between RAC and control pigs. Pigs fed RAC had less ($P < 0.01$) sort loss/cwt (\$0.15) compared with the control pigs (\$0.95). Eight control and 2 RAC fed pigs had HCW less than 76.9 kg (sort loss threshold). Ractopamine can be an important tool in improving growth and efficiency, reducing the variation in market weight and sort loss of finishing pigs.

Keywords: Paylean, Equal weight, Ractopamine hydrochloride

Table 1
Effect of RAC on growth and carcass traits.

Item	Diet		SEM	P-value
	Con	Rac		
Start BW, kg	99.49	99.63	0.81	0.89
Market BW, kg	123.86	126.87	0.49	<0.001
Days to mkt wt	29.28	26.80	0.76	0.01
ADG, kg	0.84	1.02	0.02	<0.001
ADFI, kg	2.85	2.93	0.05	0.1847
G:F ¹	0.29	0.35	0.01	<0.001
HCW, kg	88.44	91.37	0.35	<0.001
Dressing, %	71.11	72.10	0.22	<0.01
Sort loss, \$/cwt ²	-0.95	-0.15	0.20	<0.01
Loin depth, mm	58.17	59.84	0.64	0.05
Fat depth, mm	17.45	17.07	0.34	0.4
Estimated lean, %	55.2	55.63	0.24	0.18

¹Gain:feed.

²From Packer Grid.

Specific long-chain fatty acids preferentially induce differentiation of bovine intramuscular or subcutaneous preadipocytes.

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Understanding the mechanisms controlling the accumulation of distinct adipose tissue depots of cattle will facilitate efforts to selectively increase intramuscular (IM) fat or reduce subcutaneous (SC) fat. Our objectives were to compare differentiation of bovine preadipocytes isolated from IM and SC adipose tissues in response to long-chain fatty acids (FA). Clonally-derived preadipocytes or stromal-vascular (S-V) cells were suspended in medium consisting of basal medium (DMEM, 1% antibiotic-antimycotic, 50 µg/mL gentamicin sulfate, 33 µM biotin, 17 µM pantothenate, and 100 µM ascorbate) supplemented with 10% fetal bovine serum. Cells were seeded at 10,000 cells per 16 mm-diameter well, and grown to confluence at 37 °C in a humidified atmosphere containing 5% CO₂. Preadipocyte differentiation was induced by basal medium supplemented with 250 nM dexamethasone for the first 48 h, 10 µM troglitazone, 280 nM bovine insulin, 20 mM glucose, 0.5% FA-free bovine serum albumin, and FA treatment. Cells were exposed to differentiation media for 10 d, and fresh media were provided every

2 d. Morphological differentiation was assessed by quantifying the total number of cells and those containing lipid droplets stained with oil red O (ORO) in 8 fields per well. Clonally-derived IM and SC preadipocytes were used to examine the effects of 0, 25, 50, 100, or 200 μM oleic acid (OLE), linoleic acid (LIN), or arachidonic acid (ARA) on adipogenesis. Treatment \times depot interactions were observed with both OLE ($P=0.051$) and LIN ($P<0.001$). Oleic acid (50, 100 and 200 μM) and LIN (25, 50, 100, and 200 μM) increased the percentage of ORO positive SC preadipocytes compared with cells exposed to no FA. In contrast, only 200 μM OLE increased the percentage of ORO positive IM preadipocytes compared with cells exposed to no FA, and LIN had no effect on IM preadipocytes. A depot \times treatment effect ($P<0.001$) was also observed with ARA. However, the percentage of ORO positive cells was higher ($P<0.05$) than control in IM preadipocytes exposed to 50, 100, and 200 μM ARA, but only 200 μM ARA increased the proportion ORO positive SC preadipocytes. Effects of FA combinations, OLE + LIN, OLE + ARA, and LIN + ARA, were determined using each FA at 100 μM . Intramuscular and SC S-V cells isolated from 3 steers were used to examine effects of FA on heterogeneous preadipocyte populations, and to evaluate the combined effects of long-chain FA. Treatment \times depot effects ($P<0.01$) were observed with the effects of ARA, LIN, OLE, and their combinations on percent ORO positive cells. Arachidonic acid, OLE, and their combinations increased ($P<0.05$) SC preadipocyte differentiation relative to control, but only ARA increased IM preadipocyte differentiation. Combinations of OLE or LIN with ARA decreased ($P<0.05$) the proportion of ORO positive IM preadipocytes compared with ARA alone. In summary, differentiation of clonally derived bovine SC preadipocytes is induced by OLE and LIN to a greater extent than IM preadipocytes, whereas ARA appears to have the opposite effect. Because specific FA preferentially induce differentiation of bovine IM or SC preadipocytes, this information may be useful for developing strategies to improve beef quality or carcass yield.

Keywords: Bovine, Preadipocyte, Fatty acid

Influence of maternal nutrition on histology and gene expression of myoregulatory factors in fetal bovine muscle

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Given the potential variation in forage quantity and quality available to gestating cows, it is possible to encounter periods of nutrient restriction, while supplementation decisions could lead to periods of over-nutrition. Manipulation of maternal nutrition during this period has been shown to influence myogenesis in the fetuses of various species, however bovine research is limited. Further, secondary myogenesis, which is central to skeletal muscle development, occurs primarily during mid-gestation in beef cattle. Therefore, the objective of this study was to determine the effects of maternal nutrition on muscle characteristics and gene expression of fetal myoregulatory factors. Twenty-two bred Angus crossbred heifers (BW = 527.73 ± 8.3 kg) were assigned randomly to one of 3 dietary treatments providing 180% (HIGH; $n=7$), 107% (INT; $n=7$), or 88% (LOW; $n=8$) of the energy requirements for growing pregnant heifers, from d 85 to 180 of gestation. Body weight and ultrasound measurements for fat thickness (FT) and ribeye area (REA) were recorded to determine changes in dam body condition. Fetuses were removed via cesarean section at d 180 of gestation and fetal weight and crown rump length were recorded. Samples from the *longissimus dorsi* (LD) were excised from the left side of each fetus, diced, snap frozen, and stored at -80°C for evaluation of expression of select genes using real-time PCR. MyoD, Myf5, myogenin, and MRF4 were evaluated as they are essential for myoblast determination and proliferation, as well as myostatin, which

appears to mediate myoblast number and fusion. Nutrition has also been shown to influence calpastatin expression in bovine fetuses; therefore, expression of the calpain protease system was also quantified. The LD from the right side of each fetus was also dissected, fixed in paraformaldehyde and embedded in paraffin. Transverse sections, 10 μm thick, were cut and stained with hematoxylin and eosin to determine fiber area and diameter. At trial initiation, dam BW was similar among treatment groups. Final BW was lowest for the LOW dams ($P<0.05$), however final BW for INT and HIGH were similar. Ribfat thickness increased in the HIGH treatment group compared with LOW and INT dams ($P<0.05$) and HIGH heifers tended to have had greater final REA than INT and LOW heifers ($P<0.10$), which were similar. Thus, dam weight and composition were influenced by diet during the treatment period, however dietary treatment did not influence fetal weight or crown rump length ($P=0.45$ and $P=0.16$ respectively). Expression of MyoD, Myf5, and MRF4 were similar between treatments, however myogenin was more highly expressed ($P=0.04$) in the HIGH fetuses as compared with the LOW, and could indicate greater terminal differentiation of myoblasts. No differences were detected between treatment groups for expression of myostatin, m-calpain or calpastatin. However, μ -calpain showed increased expression in fetal LD ($P<0.01$) of HIGH fetuses compared with INT, but did not differ from LOW ($P=0.45$). Muscle fiber diameter and area were similar between treatment groups ($P=0.98$ and $P=0.98$ respectively). Collectively, these results suggest that fetal size and muscle development are not affected by the degree of maternal nutrient manipulation imposed during mid-gestation in this study.

Keywords: Beef, Fetal programming, Myogenesis

Differences in Minolta color score and beef tenderness associated with feedlot stress and slaughter method

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The objective was to investigate the effect of beef cattle temperament and harvest method on Minolta color scores and tenderness. Measurements of temperament including exit velocity (EV), chute score (CS), and catch score (CAPS) were obtained before slaughter on Angus \times Piedmontese crossbred heifers ($n=126$). At 14 to 16 mo of age (580 ± 43 kg), heifers were transported 30 km to a commercial slaughter facility. Heifers were harvested on 2 consecutive Mondays (64 and 62 heads, respectively) with 53 of the 64 heads on d 1 slaughtered kosher, and the remaining 73 head stunned using a captive bolt. Climatic conditions, transportation method, and duration were similar between slaughter dates. Vocalization scores (VOCAL) and blood lactate measurements (LAC) were obtained at time of slaughter. At approximately 24 h postmortem, carcass measurements and marbling scores were obtained. *Longissimus thoracis* (LT) samples were collected and transported to the North Dakota State University Meat Laboratory for packaging and 14-d aging before Minolta color score and Warner-Bratzler shear force (WBSF) measurements. Data were analyzed using Proc CORR and Proc GLM utilizing slaughter method, date, and pen as classes; with slaughter method slaughter date and pen (slaughter date) in the model. Temperament scores including CS, CAPS, and VOCAL correlated ($P<0.03$) with LAC ($r=0.267$, $r=-0.209$, and $r=0.369$, respectively). EV and CAPS were negatively correlated ($P<0.001$; $r=-0.385$). WBSF was positively correlated ($P<0.01$) to L*, a*, and b* Minolta color scores ($r=0.278$, $r=0.332$, and $r=0.359$, respectively). The LT from kosher slaughtered heifers had increased ($P<0.01$) L* (42.77 ± 0.54 vs. 40.29 ± 0.33), a* (27.72 ± 0.44 vs. 25.78 ± 0.25), b*

(8.55 ± 0.34 vs. 6.81 ± 0.20) and WBSF values (3.64 ± 0.15 vs. 3.02 ± 0.10) than that of captive bolt stunned heifers. LT from captive bolt stunned heifers had increased ($P=0.04$) marbling scores (418 ± 6 vs. 387 ± 8), and a tendency ($P=0.08$) for increased drip loss compared with that from Kosher-slaughtered heifers (0.23 ± 0.01 vs. 0.27 ± 0.01). These data indicate that chute behavior is correlated to measurements of LAC, and WBSF is significantly correlated to L^* , a^* and b^* . Our data also suggest that the Kosher slaughter method may affect Minolta color score values, as well as decrease tenderness, marbling score, and drip loss in LT when compared with the captive bolt stunning method, and warrants further research.

Keywords: Beef, Tenderness, Kosher

Storage stability of cooked pork patties containing different tomato products

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Lycopene is an acyclic carotenoid without provitamin A activity. It is a potent quencher of singlet oxygen and a scavenger of peroxy radicals, so recognized as a strong natural antioxidant. Tomatoes are considered to be rich source of lycopene. Lipid oxidation is a major factor responsible for the color and flavor deterioration of meat during storage. Therefore, the efficacy of selected levels of different tomato products such as tomato puree (T1–10%), tomato pulp (T2–12.5%) and lyophilized tomato peel (T3–6.0%) were evaluated in cooked pork patties during refrigerated aerobic storage. The patties were formulated with 1.5% salt and 10% added back fat and cooked in preheated oven at 175 °C. The control patties were formulated as described above without any tomato products. The samples were drawn at 5 d intervals up to 20 d for the evaluation of various physico-chemical and sensory parameters. The number of observations recorded per treatment were 6 for physicochemical parameters, whereas 21 for sensory evaluation. Two-way ANOVA was carried out and significance was drawn using Duncan's Multiple Range Test. The pH was higher ($P<0.05$) in the control than all the tomato-treatments and was lowest in T3. The pH decreased for all the products linearly throughout the storage. Beta-carotene and lycopene content was highest in T3 and declined during the storage. The L^* value was lower ($P<0.05$) in T3 whereas a^* and b^* values were highest in T3. Percentage metmyoglobin formation was higher ($P<0.05$) in the control patties than all the tomato-treated patties and increased linearly throughout the storage period. However, the rate of increase was higher ($P<0.05$) in the control than tomato-treated products. Peroxide value, free fatty acid content and lipid oxidation were lower ($P<0.05$) in the tomato treatments than the control and increased throughout storage. Sensory scores for color and appearance were higher ($P<0.05$) in T1 and T2 than in T3 and the control on 0 d and this trend continued throughout the storage. All the tomato-treated groups exhibited higher oxidative stability in comparison to controls during the entire storage. Incorporation of 6% lyophilized tomato peel (T3) demonstrated greatest improvement in color, flavor, and oxidative stability of refrigerated pork patties.

Keywords: Lycopene, Pork patties, Tomatoes

Evaluation of a solidstate fermented apple byproduct feed on nutrient content and quality of pork meat

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Including fermented apple by-products in an animal diet may modify the quality of meat due to their effects on biochemical processes, which are consequently reflected in nutrient content, physicochemical and oxidative processes of animal muscles. The aim of present work was to evaluate the effect of a diet containing a solid-state fermented apple by-product (SFA) and a fibrolytic enzyme (ENZ) on the quality of pork meat. Twenty-four Landrace × York pigs 38.9 ± 3.6 kg were randomly assigned (4 per treatment) and fed during 9 weeks with an isoprotein and isoenergetic diet including different levels of SFA and ENZ; T0–0 (0% SFA–0% ENZ), T0–0.1 (0% SFA–0.1% ENZ), T5–0 (5% SFA–0% ENZ), T5–0.1 (5% SFA–0.1% ENZ), T10–0 (10% SFA–0% ENZ) and T10–0.1 (10% SFA–0.1% ENZ). Pigs were slaughtered when they reached 102 ± 1.8 kg. Samples of *Longissimus dorsi* muscle, taken from within the 10th and the 12th ribs, were analyzed to determine crude protein (CP), intramuscular fat (IMF), moisture (MC), organic matter (OM), ashes (AS) content, pH, water holding capacity (WHC), L^* , a^* , b^* (D65/10°) and TBARS. Data was analyzed considering a completely randomized design with SFA and ENZ as fixed effects using MIXED procedure and PDIF statement by SAS software. MC, AS and OM were affected by SFA ($P<0.05$) and ENZ ($P<0.05$), CP and IMF were affected by the SFA ENZ interaction ($P=0.0002$). T0–0.1 showed the highest CP content while T10–0.1 the lowest ($P<0.05$). Although T0–0 presented one of the lowest CP contents, it did not show significant differences with the highest and lowest ($P>0.05$), which might indicate that an increase of SFA or ENZ addition in the pigs diet did not affect negatively the CP content. In contrast to CP performance, IMF increased for T10–0.1 while for T0–0 decreased ($P<0.05$), being the lowest IMF content. It is possible that increasing SFA and ENZ addition in the diet, an increase in the IMF percentage occurs in the meat without rising the CP. T0–0 was higher in MC ($P<0.05$), AS ($P<0.05$) and lower in OM ($P<0.05$) than the others treatments. pH was affected by ENZ ($P=0.0441$), particularly for T5–0, which showed the lowest pH ($P<0.05$), whereas the rest of the treatments were similar ($P>0.05$). WHC, L^* , a^* , b^* and TBARS were not affected by SFA or ENZ ($P>0.05$), nevertheless mean differences were observed. Regarding L^* values, T0–0 was the highest and T10–0 the lowest ($P<0.05$); for a^* values, those treatments were not different ($P>0.05$). Moreover, T5–0 showed the highest and T10–0.1 the lowest a^* value ($P<0.05$). TBARS quantification was higher for T5–0 while T5–0.1 was the lowest one ($P<0.05$). Respecting T0–0, there were no differences between the highest and lowest values ($P>0.05$). SFA or ENZ addition did not affect fat oxidation level. The results obtained suggest that 10% of SFA addition generates meat with high CP content, IMF and MC intermediate, more stable pH values and lower oxidation levels. SFA and ENZ addition to pig diet increase the CP and IMF content, keeping adequate pH, WHC, lightness and oxidation levels.

Keywords: Apple by-product, Pork quality, Meat

Table 1
Nutrient content and physicochemical characteristics of pork.

Nutrient	T0–0	T0–0.1	T5–0	T5–0.1	T10–0	T10–0.1
CP	24.7 ± 0.4	26.4 ± 0.4	25.2 ± 0.5	25.9 ± 0.4	26.2 ± 0.4	23.3 ± 0.4
IMF	0.6 ± 0.03	1.3 ± 0.03	2.6 ± 0.04	1.3 ± 0.03	1.4 ± 0.03	2.9 ± 0.03
MC	72.4 ± 0.2	71.2 ± 0.2	71.3 ± 0.3	70.5 ± 0.2	71.5 ± 0.2	71.4 ± 0.2
pH	5.7 ± 0.04	5.7 ± 0.04	5.6 ± 0.05	5.6 ± 0.04	5.7 ± 0.04	5.7 ± 0.04
WHC	60.4 ± 1.6	61.5 ± 1.6	59.4 ± 1.9	61.3 ± 1.6	57.8 ± 1.6	59.4 ± 1.6
L^*	51.9 ± 3	50.5 ± 3	50.4 ± 3	48.1 ± 3	41.2 ± 3	49.2 ± 3
a^*	3.7 ± 0.9	4.0 ± 0.9	5.4 ± 1	5.1 ± 0.9	3.5 ± 0.9	1.9 ± 0.9
b^*	15.3 ± 0.8	15 ± 0.8	14.4 ± 1	16.1 ± 0.8	13.8 ± 0.8	14.1 ± 0.8
TBARS	647.6 ± 42	679 ± 49	780.5 ± 49	635.3 ± 42	638.1 ± 49	654.3 ± 42

Comparison of Tulathromycin and Tilmicosin on the prevalence and severity of bovine respiratory disease in feedlot cattle in association with feedlot performance and carcass characteristics

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The objectives of this study were 1) to investigate the effects of metaphylactic treatment for bovine respiratory disease (BRD) on feedlot performance and carcass characteristics, and 2) evaluate the effect of lung lesion prevalence and severity with carcass characteristics. Cattle ($n=2,362$) initially weighing 310.5 ± 31.3 kg were purchased from sale barns in Oklahoma and allocated in a randomized complete block design to one of three treatments (CON—no metaphylactic treatment; TUL—Tulathromycin at 0.499 mL/100 kg body weight; TIL—Tilmicosin at 0.680 mL/100 kg body weight). Pen ($n=24$) served as the experimental unit for objective 1; the individual animal served as the experimental unit for objective 2. Cattle requiring further prophylactic treatment were administered Ceftiofur (0.680 ml/100 kg body weight). Lungs of all steers were evaluated during harvest to assess presence or absence of pneumonic lesions in the anteroventral lobes, presence or absence of pleural adhesions, and an evaluation of the bronchial lymph nodes. Response variables included dry matter intake, average daily gain, gain:feed, shrunk live weight, lung lesion score, hot carcass weight, dressed yield, 12th rib fat depth, longissimus muscle area, calculated yield grade, marbling, quality grade, and calculated empty body fat. No significant difference for any response variable was found between TUL and TIL, therefore, further analysis for attributes was conducted as contrasts between metaphylactic treatments and CON. Incidence of BRD associated morbidity was observed at a rate of 9.65% whereas BRD related mortality occurred at rate of 2.24%. Lung lesions were present in 64.3% of lungs and were distributed almost equally between metaphylactic (63.9%) and control (65.1%) cattle. Compared to the CON treatment, cattle treated via metaphylactic therapy had greater ($P<.05$) average daily gain, gain:feed, shrunk live weights, dressed yield, hot carcass weight, 12th rib fat depth, and empty body fat. Steers with lung lesions had decreased ($P<.05$) hot carcass weights, less internal kidney, pelvic and heart fat, less 12th rib fat depth, decreased yield grade, decreased marbling scores, and empty body fat than steers without lesions.

Keywords: Metaphylactic, Respiratory lesions, Bovine respiratory disease

Analysis of the questionnaire with dendrograms based on CART models

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Traditional Czech cuisine involves pork, chicken, fish and beef. Whereas the meal from the first 3 species is prepared by many ways including grilling, the majority of the Czech population does not use grilling for beef. Beef is mainly used to prepare goulash or is stewed, served with soup and rice or dumplings. The purpose of our study was to evaluate relationship between consumer characteristics (gender, age, educational attainment, frequency of purchasing of meat, the most frequently bought and the most favorite species) and preference for cooking method of beef, degree of doneness of steaks and origin of beef. Completing the questionnaires (15 questions) was followed by rating of samples of grilled beef steaks to find out preference for beef from bulls or cows. Data gained from survey forms were evaluated with CART—Classification and Regression Tree models fitted in the package rpart,

version 3.1–41 in the R software, version 2.7.2. The package allows quick view and further selection of significant factors and evaluation of their ratio of explained variability with effective visualization of their gradual relationship by dendrogram. The second aim of our work was to draw attention of scientists to this effective method of visualization of results from questionnaire. The total number of respondents was 132 (people qualified in agriculture) with the average age of 38.6, ranged from 11 to 73. There were 14 respondents with primary, 41 with secondary and 74 with university education. Results based on the question “What species do you consume most often?” were: 10% of respondents marked fish, 2.4% lamb, 19.4% beef, 40% pork and 27% chicken. Results based on the question “What species is your favorite?” were 16% marked fish, 7.4% lamb, 29% beef, 29% pork and 18.5% chicken. Difference between preferences for the most often consumed and the most favorite species was significant ($\text{Chi-sq}=18.49$, $\text{df}=4$, $P<0.00098$). The dendrogram regarding to beef showed that beef is preferred by respondents who had grilled beef yet and attained to university education or were younger than 48.5 years. Ratios of methods of cooking beef were: 27% stewing, 35.6% baking, 20% boiling and 43% grilling with the following degrees of doneness: 3.78% rare, 8.3% medium rare, 35.6% medium, 27% medium well, 23.5% well done. Degree medium was preferred by consumers who had had a grilled steak, and usually buy beef 1 times a week or month, are interested in origin of beef and do not eat chicken (this cascade of significant criterions appeared on the left branch of dendrogram). On the contrary, the right branch of the dendrogram showed that consumers who have not had a steak marked well done. Another terminal branch showed that respondents buying and grilling beef prefer medium, whereas the respondents who do not grill beef prefer medium well. As concern to the origin of beef, the model showed that the interest in beef of domestic production was higher in respondents whose age was greater than 24.5 years and prefer well-done steak. Among the consumers was possible to distinguish those who prefer steaks from bulls from those who prefer steaks from cows. Age in the latter group was higher than 51.5 or younger with preferences for well-done steak and grilling method. Our results indicate changes in consumer habits and their variability in the Czech Republic.

Keywords: Survey, Beef, Dendrogram

Product packaging trends in retail meat cases by species

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Retail meat cases are steadily evolving in the United States. Packages have become more informative, case ready, and have also become more attractive to consumers. Trends in the packaging industry need to be followed to inform the retail distributors of the marketplace demands of consumers. The objective of this study was to evaluate the current trends in retail meat packaging by species. Packaging types were evaluated in 131 retail meat cases throughout the country. Packages were evaluated for packaging type, tray color, tray type, and case ready. All packages were categorized by species including beef, ground beef, pork, chicken, turkey, lamb, and veal. All data were imported into a commercially available software package and analyzed using the proc FREQ procedure in the Statistical Analysis System (SAS) 9.1.3 software. Polyvinyl chloride (PVC) packaging was most commonly used with 45% of fresh meat packages being PVC. Modified atmosphere packaging (MAP) was 14.8%, Simple Steps (SS)

was 14.1%, and laminate was 13.5%. MAP packaging was most widely used in ground beef, turkey, lamb, and veal; while laminate was most commonly used for pork and turkey. Most commonly used tray colors were white (31.6%) and black (25.3%) with white being used more with turkey and black primarily used for beef cuts. Yellow trays were used most commonly in chicken with 37.7% of packages containing yellow trays. Tray type varied with 62.2% of all trays being foam and 14.6% being rigid plastic. Case ready products comprised 61% of the fresh meat case with chicken (92.9%) and turkey (93.6%) being the main contributors. This study confirms the trends noticed in previous research that PVC is the most common packaging type with foam trays being the most common, as well as poultry products comprising the majority of the case ready packages.

Keywords: Retail meat case, Packaging

Investigating types of fresh meat products in the fresh meat retail case and distribution of retail space across the United States

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The objective of this study was to further investigate trends of the retail fresh meat case focusing on fresh meat products and retail space in 131 stores nationwide across 5 regions of the United States in 2007. The United States was divided into Mountain/Southwest, Midwest, Northeast, Southeast, and West Coast. Categories recorded for the self-service case were whole muscle beef cuts, ground beef, pork, veal, lamb, chicken, turkey, fresh sausage, value-added, heat and serve, ham bone-in, ham boneless, ham steak, processed meat, seafood, nonmeat, and offal. Categories recorded for the full-service were seafood, beef, pork, chicken, ground beef, lamb, fresh sausage, turkey, veal, and nonmeat. One hundred percent of the stores, across regions had whole muscle beef cuts, ground beef, pork, chicken, turkey, fresh sausage, and heat and serve. Lamb (76.0%–96.0%) and value added (81.4%–96.5%) products were found in almost all stores. Veal was most commonly found in the Northeast region (96.0%), but was least likely to be found in the Mountain/Southwest (36.0%) region. Seafood products dominated the full-service meat case with 88.2% to 100.0% of stores carrying seafood products across regions. Nationally, whole muscle beef cuts, pork, chicken, and ground beef were the second most commonly found fresh products found in the full-service meat case (61.1% to 69.5%). Overall, the Mountain/Southwest region had the most linear meters dedicated to the fresh meat self-service case (91.8 m) whereas the Southeast Region had the least (79.4 m). Whole muscle beef cuts (12.3 m to 15.6 m), chicken (11.5 m to 15.9 m), and pork (8.4 m to 11.8 m) occupied a greater portion of the retail met case compared to other categories. Veal (1.0 m to 1.8 m), lamb (1.2 m to 2.0 m), offal (1.2 m to 2.6 m), and ham steak (0.8 m to 1.9 m) had the least linear meters dedicated to the fresh meat case. Linear meters for the full-service meat case was predominately dedicated to seafood (3.5 m to 5.2 m) followed by whole muscle beef cuts (1.2 to 2.0 m). Turkey had the fewest linear meters (0.0 to 0.2 m) dedicated to the full-service meat case.

Keywords: Retail, Market survey

Moderate exercise has minimal effect on meat quality traits in finishing heifers

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Exercising beef cattle is an alternative production practice employed by an increasing number of producers seeking to meet changing consumer demands. However, little scientific data are available on how exercise effects beef quality traits. The objectives of this study were to document the effects of moderate forced exercise on meat quality traits in feedlot cattle. Crossbred heifers ($n=30$; 448 ± 7.1 kg initial BW) were used in a randomized complete block experiment to assess impact of exercise regimen on postmortem pH, instrumental CIE L*, a* and b* values, Warner Bratzler shear force values and fatty acid concentration. Heifers were stratified by initial BW and assigned randomly, within strata, to Sedentary and Exercised groups. Cattle were housed in individual pens (1.5 m x 6.5 m) and fed a finishing diet consisting of 93% concentrate and 7% roughage. Each Mon, Wed, and Fri, Exercised cattle were removed from their pens and forced to move by an animal handler on foot at a pace of 5 to 6 km/h (20 min/d for the first 2 weeks, 30 min/d for the next 2 weeks, and 40 min/d for a total of 8 weeks). Cattle ($n=16$) remained in strata which were randomly selected and harvested at the Kansas State University Meat Laboratory. An initial pH measurement was collected at the beginning of the chilling period in the *longissimus dorsi* dorsal to the 12th rib and in the *semimembranosus* posterior to the *ischium* with additional measurements being collected every h for 12 h and a final pH collected 24 h postmortem. Instrumental lean color values were collected on the *longissimus dorsi* at the cut surface between the 12th and 13th ribs. Carcasses were fabricated and steaks were removed from 4 muscles; *longissimus dorsi*, *triceps brachii*, *semitendinosus*, and *semimembranosus* to represent support or locomotion muscles. Steaks were packaged and aged for 14 d postmortem and used for instrumental tenderness and fatty acid analysis. Data were analyzed using the Mixed procedure of SAS, with fixed effect of exercise regimen and random effects of strata and exercise regimen x strata. For pH, time postmortem and the interaction between time postmortem and exercise regimen were included as fixed effects for repeated measures. Exercise did not affect initial pH, rate of pH decline or final pH for either location ($P>0.05$). Exercise cattle displayed no difference ($P>0.05$) in instrumental L* values, but displayed increased ($P<0.05$) a* and decreased ($P<0.05$) b* values when compared with Sedentary cattle. No differences ($P>0.05$) were observed in Warner Bratzler shear force values for *longissimus dorsi* (4.08 vs. 3.46 kg), *triceps brachii* (3.76 vs. 3.77 kg), *semitendinosus* (4.68 vs. 4.28 kg), or *semimembranosus* (4.52 vs. 4.42 kg) when comparing Exercise vs. Sedentary treatments. In addition, no differences ($P>0.05$) were detected for any saturated, monounsaturated, polyunsaturated or total fatty acid concentration from any of the 4 muscles tested. In conclusion, moderate forced exercise did not affect pH measurements, Warner Bratzler shear force values, fatty acid concentrations, or L* values. Exercise cattle showed higher a* values and lower b* values compared with Sedentary cattle, indicating a change in instrumental color.

Keywords: Cattle, Exercise, Meat

Effects of pea chips on pig performance, carcass quality and composition, and palatability of pork

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Pea chips are produced as a by-product when field peas are processed to produce split peas for human consumption. The objective of this experiment was to test the hypothesis that inclusion of pea chips in diets fed to finishing pigs does not negatively influence pig growth performance, carcass composition, and the palatability of pork. A total of 24 barrows (initial BW: 58.0 ± 6.6 kg) were allotted to 1 of 4 treatments and fed early finishing diets for 35 d and late

finishing diets for 35 d. A corn–soybean meal (SBM) control diet and 3 pea chips containing diets were formulated within each phase. Pea chips replaced 33.3, 66.6, or 100% of the SBM in the control diet. Pigs were housed individually and all pigs were sacrificed at the conclusion of the experiment. Overall, there were no differences in final BW, ADFI and G:F of pigs among treatments; but, there was a quadratic response in ADG ($P=0.04$) with the smallest value observed for pigs fed the control diet. Dressing percentage linearly decreased ($P=0.04$) as pea chips replaced SBM in diets; but, there were no differences among treatments in HCW, LM area, 10th rib back fat, lean meat percentage, and marbling. Likewise, pH in loin and ham, drip loss, and purge loss were not influenced by treatment. However, there was a quadratic response ($P=0.08$) in 24-h pH in the shoulder with the smallest value present in pigs fed the diet in which 66.6% of the SBM was replaced by pea chips. Subjective LM color and JCS scores were reduced (quadratic, $P=0.03$ and $P=0.05$, respectively) and LM b^* values and hue angle were increased (quadratic, $P=0.09$ and $P=0.10$, respectively) when pea chips replaced SBM in the diets. Ham L^* (quadratic, $P=0.04$), a^* (linear, $P=0.02$), b^* (quadratic, $P=0.07$), color saturation (linear, $P=0.02$), and hue angle (quadratic, $P=0.05$) were increased when pea chips replaced SBM. However, there were no differences in shoulder and fat color. Moreover, cook loss percentage, shear force, juiciness, and pork flavor of pork chops were not different among treatments; but, tenderness of pork chops linearly decreased ($P=0.04$) as SBM replaced pea chips. It is concluded that all the SBM in diets fed to growing-finishing pigs may be replaced by pea chips without negatively influencing growth performance or carcass composition. However, pigs fed pea chips will have pork chops and hams that are lighter in color and chops may be less tender if pigs are fed pea chips rather than corn and SBM.

Keywords: Pea chips, Pork, Quality

Effect of high protein dried distillers grains used in beef cattle finishing diets on fatty acid profile, and retail shelf life in fresh and further processed products

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Angus steers ($n=48$) were individually fed one of 3 dietary treatments in the finishing phase that included a conventional corn based finishing diet (CON); a treatment containing 35% dried distillers grains with solubles replacing dry rolled corn (BPX); and a treatment containing 35% high protein dried distillers grains replacing dry rolled corn (HP). After 118 d on treatment, cattle were humanely harvested at a commercial abattoir and strip loins (IMPS #180), shoulder clods (IMPS #114), and inside rounds (IMPS #169) were removed 24 h postmortem. Subcutaneous adipose tissue from the anterior end of strip loins was analyzed for fatty acid profile. Two, 2.54 cm thick steaks were serially cut from the anterior end of each strip loin. Inside rounds were ground twice (0.375 cm) and blended for fresh ground beef. Shoulder clods were ground twice (0.375 cm) and blended meat blocks (4 animals/treatment) were divided into 2 batches (9.1 kg) one for summer sausage and one for bologna. Blended meat blocks were mixed with seasoning and culture (summer sausage) and stuffed into fibrous casings, and cooked to an internal temperature of 71 °C, chilled (4 °C) and sliced. Strip steaks and ground beef were placed on polystyrene trays and overwrapped with PVC, while sausage slices were individually placed on polystyrene trays, and vacuum packaged. All products were stored at 4 °C under cool white fluorescent lighting and evaluated objectively (L^* , a^* , b^*) and subjectively (lean color, surface discoloration and overall acceptability) every 24 h for the duration of the study starting at d 0. Ground beef samples were

collected at d 0 and d 6 for evaluation of lipid oxidation (TBARS). Treatment had no effect on saturated fatty acid and monounsaturated fatty acid percentage ($P=0.44$ and 0.86 respectively), however; treatment did affect mean polyunsaturated fatty acid ($P=0.0001$), with CON having decreased values as compared with BPX and HP. TBARS indicated no difference between treatments on d 0 ($P=0.50$) for lipid oxidation, however, on d 7 HP had increased values as compared with BPX and CON ($P=0.001$). For strip steak retail evaluation, treatment did not affect mean L^* or b^* values ($P=0.87$ and 0.43 , respectively), however; treatment did affect mean a^* values ($P=0.0001$). Redness values were increased for CON as compared with BPX and HP. Treatment affected subjective lean color, surface discoloration and overall appearance ($P=0.0001$) of strip steaks. Objective analysis of ground beef, summer sausage, and bologna indicated that treatment did not affect mean L^* , a^* , or b^* values ($P=0.15$, 0.16 , and 0.23 respectively). CON ground beef had a more desirable subjective lean color ($P=0.001$) and overall appearance ($P=0.001$) than BPX and HP. Treatment affected bologna subjective lean color and surface discoloration ($P=0.07$ and 0.10 , respectively), however; treatment did affect mean overall appearance ($P=0.03$), with increased values for CON as compared with BPX and HP. For summer sausage, there was no effect of treatment on subjective characteristics. Results indicate that high protein dried distillers grains may increase lipid oxidation resulting in a decrease in shelf life.

Keywords: Beef quality, Fatty acid, Shelf life characteristics

Effect of high protein dried distillers grains used in beef finishing diets on carcass characteristics, shear force, and moisture loss of fresh beef

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Angus steers ($n=48$) were individually fed one of 3 dietary treatments in the finishing phase that included a conventional corn based finishing diet (CON); a treatment containing 35% dried distillers grains with solubles replacing dry rolled corn (BPX); and a treatment containing 35% high protein dried distillers grains replacing dry rolled corn (HP). The inclusion of BPX and HP was in place of corn. After 118 d on treatment, cattle were humanely harvested at a commercial abattoir and hot carcass weight, 12th rib back fat, percent kidney pelvic heart fat, ribeye area, marbling score, USDA yield grade and quality grade were evaluated. Strip loins (IMPS #180), shoulder clods (IMPS #114), and inside rounds (IMPS #169) were removed 24 h postmortem and used for further analysis. Packaging purge loss of the inside round, strip loin and shoulder clod was calculated after transport and further fabrication. Steaks were serially cut, 2.54 cm thick, from the anterior end of each strip loin. Drip loss was evaluated for the first steak by suspending for 24 h at 4 °C in a controlled atmosphere. Duplicate steaks were cooked to an internal temperature of 71 °C, cooled to room temperature, cored and evaluated for Warner-Bratzler shear force. Dressing percent was not different among treatments ($P=0.22$). Hot carcass weight, 12th rib back fat, and percent kidney pelvic heart fat were similar among treatments ($P=0.54$, 0.54 , 0.18 , and 0.35 respectively). Ribeye area was similar ($P=0.57$) and averaged 78.1 cm² for all treatments. Average USDA yield grades were similar ($P=0.54$) for CON, BPX, and HP (2.56, 2.75, and 2.69 respectively). Marbling scores (where 500 = small⁰⁰, 600 = modest⁰⁰) were not different ($P=0.26$) across treatments. Fabrication loss was not different across treatments for the inside round, strip loin, and shoulder clod ($P=0.20$, 0.36 , and 0.20 , respectively). Mean drip and purge losses were similar across treatments ($P=0.49$ and 0.16 , respectively). Mean shear force values

for CON, HP and BPX did not differ among treatments ($P=0.25$) and averaged 2.54, 2.37, and 2.88 kg, respectively. Results indicate that beef cattle finished on diets containing high protein dried distillers grains may successfully replace up to 35% of corn grain in feedlot diets and not affect carcass characteristics, moisture loss, and shear force of fresh beef products.

Keywords: Beef quality, Carcass characteristic, Moisture loss

Qualitative attributes of nationally available grass-fed beef

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The objective of this study was to assess the variability of qualitative attributes associated nationally available grass-fed beef, including: product cost, distance traveled, distribution CO₂ emissions, uncooked color for different bloom times, and cooked color and tenderness at different endpoint temperatures. Frozen ground beef (GB, 1000 g per vendor) and beef *longissimus lumborum* steaks (LL, 4 per vendor) were purchased from online grass-fed beef vendors ($n=15$) from the United States and shipped to the Penn State Meats Laboratory via air freight. Only beef from vendors willing to provide postmortem aging information supplied beef for this study (14–21 d). Sample cost per kg and shipping container dimensions were recorded, and samples were stored at -20°C until all samples were collected. Standard cargo volume, fuel economy, and emissions data were used to calculate possible CO₂ emissions associated with product shipment, and other cargo factors were taken into account. GB and LL steaks thawed overnight at 2°C . GB patties (113.4-g) were made with a hand mold. Instrumental color (L^*, a^*, b^*) was measured after GB patties and LL steaks bloomed for 0, 30, and 60 min at 20°C . GB patties and LL steaks (4 per vendor) were cooked using clamshell-style grills to 60, 65.5, 71, and 76.6°C , allowed to rest for 10 min, then internal cooked color was measured. Warner-Bratzler shear force was conducted on 4 1.27-cm cores taken parallel with the muscle fiber of each LL steak, and on 2 2.5-cm thick strips from each cooked patty. LL steak retail price was $\$50.3 \pm 16.7/\text{kg}$ and GB retail price was $\$13.4 \pm 2.8/\text{kg}$. Beef was shipped 1904.5 ± 1098.4 km with potential CO₂ emissions of up to 9.9 kg CO₂/kg beef. The a^* values after 0, 30, and 60 min of bloom time of uncooked LL steaks were 11.4 ± 2.5 , 15.6 ± 3.2 , and 16.6 ± 3.2 , and of uncooked GB patties were 20.6 ± 5.6 , 22.6 ± 3.5 , and 21.9 ± 3.5 , respectively. The a^* values after cooking to 60, 65.5, 71, and 76.6°C for LL steaks were 13.5 ± 3.5 , 12.2 ± 3.8 , 9.5 ± 2.3 , and 7.9 ± 1.8 , and for GB patties were 19.7 ± 4.1 , 18.8 ± 2.9 , 18.4 ± 3.1 , 18.7 ± 3.8 , respectively. The WBSF values for endpoint temperatures of 60, 65.5, 71, and 76.6°C for LL steaks were 6.7 ± 1.2 , 8.0 ± 2.6 , 7.5 ± 1.6 , and 8.5 ± 3.5 kg, and for GB patties were 10.2 ± 2.5 , 10.1 ± 4.0 , 9.5 ± 2.3 , 9.1 ± 2.3 kg, respectively. Survey data indicate that online-purchased grass-fed LL steaks and GB are considerably more expensive per kg than conventional counterparts. CO₂ emissions per kg of beef if shipped overnight can be $\geq 200\%$ more than beef shipped by truck, though may be required when niche products are direct marketed. Proponents of grass-fed beef report that it cooks differently than grain-fed beef; however, this survey reveals considerable variation of cooked color and tenderness among grass-fed products. Food miles and CO₂ emissions are emergent food qualities, neither of which is supported by products shipped via air. Grass-fed beef introduces more variation into a beef system that targets product consistency and uniformity.

Keywords: Grass-fed, Production system, Environment

Testing for the presence of *Salmonella* in dog treats through in plant validation, inoculation, and cooking

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Salmonella is a continual problem within the pet food industry. The objective of this experiment was to determine the prevalence of *Salmonella* in various dog treats through an in-plant analysis study and an inoculation challenge study. For the in-plant analysis study, 30 raw and cooked samples of lamb lung cubes, taffys (weasands), flossies (steer pizzles), and jumbo flossies were delivered to the Texas Tech University Food Microbiology Laboratory on ice and analyzed by the FDA approved BAX system method for detection of *Salmonella*. For the raw products: 7 of 30 taffys, 0 of 30 lamb lung cubes, 26 of 30 flossies, and 29 of 30 jumbo flossies were positive for *Salmonella*. For the cooked products, 1 of 30 taffys was positive for *Salmonella*, while the other products had no positive cooked samples. For the inoculation challenge study, 2 different lots of raw samples of liver tripe steaks, lamb lung cubes, taffys, and flossies were delivered on ice. Fifteen samples from each lot of products were inoculated with a 4-strain *Salmonella* cocktail at 10^{2-5} cfu/g. After a 30 min attachment period, 5 control samples were sampled for initial concentration, while the rest were cooked in accordance with the standard cooking procedure established by the company. Before and after cooking samples were serially diluted and plated onto xylose lysine deoxycholate agar (XLD) with a tryptic soy agar overlay for injured cells. If no colonies were present on XLD plates, detection was performed by the BAX system and immunomagnetic separation (IMS) with Remel *Salmonella* agglutination kit for confirmation. Statistical analysis was performed using SAS program with a 0.05 α -value for significance. Lamb lung cubes were significantly reduced by 2.85 logs with one positive sample after cooking (<10 cfu/g present) ($P<0.001$). Liver tripe steaks were significantly reduced by 3.11 logs with no positive samples after cooking ($P<0.001$). Taffys were significantly reduced by 2.85 logs with no positive samples after cooking ($P<0.001$) and the flossies were significantly reduced by 5.47 logs with no positive samples after cooking ($P<0.001$). Based on both studies it was recommended that the taffy's processing/cooking procedure should be modified to ensure safeness in case of high contamination. Although no positive raw samples were found in the in plant analysis study, the inoculation challenge study suggests that the processing and cooking procedure in case a high level of contamination with *Salmonella* occurred.

Keywords: *Salmonella*, Dog treats

Pork quality and carcass composition of market hogs farrowed from gilts provided exercise during gestation

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The transition of the swine industry from gestation stalls to group housing has led to research evaluating the impact of exercise on gestating females and their subsequent offspring. The objective of this study was to determine the effects of exercise during gestation on the subsequent offspring growth, carcass composition, and ultimate pork quality. Yorkshire gilts of similar body composition were housed in individual stalls during gestation (CON; $n=4$) or housed in individual stalls but also exercised 30 min, 3 times per week (EX; $n=4$) from d 40 to 105 of gestation. Exercise was monitored by the number of steps taken during each exercise bout and gilts were allowed to move at their own pace. The heaviest and lightest boar and gilt piglets in each

litter were selected for necropsy within 12 h of birth. Of the remaining piglets, 30 CON (n = 15 barrows and 15 gilts) and 20 EX (n = 11 barrows and 9 gilts) were fed to final market weight (avg. 118 kg). Twenty-three barrows (11 CON and 12 EX) were individually penned to evaluate feed efficiency. The remaining pigs 27 pigs were randomized and assigned to 9 pens with 3 or 4 treatment pigs per pen and additional filler pigs added to standardize pen number at 6 pigs per pen. The statistical model included treatment (TRT), sex, TRT sex, litter TRT, and pen type. Body weight was obtained daily for the first 7 d, then weekly to an average 16 kg BW, then at 14 d intervals through finishing. No differences were observed for growth, final BW, hot carcass weight, external fat thickness, or loin muscle area ($P > 0.20$). Control pigs had lesser ($P = 0.03$) 45 min postmortem longissimus pH (CON = 5.93 vs. EX = 6.21), greater ($P = 0.02$) L* values (CON = 55.87 vs. EX = 52.61), and greater ($P = 0.04$) percentage 10th rib loin muscle drip loss (CON = 6.50% vs. EX 4.59%). Interestingly, a TRT sex interaction ($P = 0.012$) was observed for 45 min postmortem pH. Control barrows had a lesser 45 min pH = 5.78 vs. CON gilts pH = 6.06 contrasting with EX barrows which had a greater 45 min pH = 6.46 vs. EX gilts at 5.96. Further research is necessary to determine if physical activity during gestation alters the sow uterine environment in a manner that influences fetal myogenic changes in muscle fiber metabolic properties that could ultimately influence fresh pork quality.

Keywords: Pork quality, Exercise, Carcass composition

Investigating composting as a viable means of disposing of goat tissue resulting from the harvest and fabrication process

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The objective of this study was to determine the effectiveness of composting as a way of disposing of tissues resulting from the harvest and fabrication of cull doe goats. The by-products from the harvest of 18 cull doe meat goats were composted in a grass/straw mixture over a 90 d period at the Kansas State University Composting Facility. Goat by-products were randomly assigned 1 of 3 treatments: bones only, offal + head, and whole (bones, skull, and offal) piles. Additionally, the pile location was randomly selected to block for variability caused by pile placement. Temperature measurements were taken weekly and decomposition scoring was completed at 30, 60, and 90 d. Separate decomposition scores were assigned by 5 panelists for bones, offal + hide, and skulls at 30, 60 and 90 d. Decomposition was measured on a scale of 1–5 with 1, indicating complete decomposition and 5, indicating no decomposition. All of the treatments increased ($P < 0.05$) in temperature from wk 1 to wk 7 but began to decrease in temperature after wk 9. For wk 1, wk 2, wk 4, and wk 5, temperatures for bone piles were less than ($P < 0.03$) offal + head and whole pile treatments, but were not different ($P > 0.05$) than the other treatments for the rest of the time periods measured. Whole piles had the greatest mean temperature for any single wk measurement of 54 °C at wk 9 and the greatest ($P < 0.03$) mean temperature of 46 °C for the entire 12 wk composting period compared with 44 °C for offal + head piles and 40 °C for the bone only piles. Bone decomposition progressed over the 90 d study; at d 60, bones in the whole piles decomposed to a greater degree ($P < 0.01$) than bone only piles. Similarly, skulls decomposed over the 90 d period with no soft tissue present at the end of the composting period. At d 60 and 90, skulls in whole piles were more decomposed ($P < 0.02$ and $P < 0.01$, respectively) than skulls in offal + head piles. Soft tissues including meat, fat, offal, and hides decomposed at the fastest rate with no differences ($P > 0.19$) between treatment types and complete disappearance by the end of

the composting period. Although no soft tissue remained on any of the skulls or bones at the end of the composting period, none of the entire skull or bone pieces were completely decomposed. In summary, composting cull doe goat tissues for 90 d resulted in complete decomposition of all soft tissues. However, complete decomposition of bones or skulls was not achieved.

Keywords: Compost, Decomposition, Goat

Fatty acid profile of meat obtained from DHA/EPA and CLA-supplemented pigs

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The objective of this work was to study the fatty acid profile of pigs fed with diets supplemented with n–3 fatty acids (docosapentanoic, DHA, and eicosapentanoic, EPA, acids) and conjugated linoleic acid (CLA). Thirty 2 castrated males, 54 kg, were randomly assigned to 4 supplementation treatments: 1) DHA/EPA; 2) CLA; (DHA/EPA) + CLA; 4) blank. The animals were supplemented for 8 weeks: 4 weeks with 2.7 g EPA, 1.8 g DHA, 15 g CLA, and 4 weeks with 3.6 g EPA, 2.4 g DHA, 20 g CLA. They were then stunned and slaughtered; 24 h postmortem, samples were taken from adipose tissues (renal, pericardial, mesenteric and dorsal) and methylated by reflux using 0.5 N NaOH-methanol and 12% boron trifluoride-methanol. The methylated fatty acids were analyzed in a gas chromatograph (Agilent Technologies 6890 N Network GC System) coupled to a mass spectrometer detector (Agilent Technologies 5975B VL MSD). Fatty acids from 10 to 22 C atoms, including DHA, EPA and CLA, were identified in animals supplemented with DHA/EPA and (DHA/EPA) + CLA. DHA and EPA concentrations showed no significant differences for these 2 treatments ($P = 0.107$ and 0.32 for DHA and EPA, respectively). Seven CLA isomers were also found in animals supplemented with (DHA/EPA) + CLA and CLA. However, concentration of isomer 9-cis,11-trans, the most metabolically active CLA form, depended on the anatomical origin of fat ($P = 0.0084$). It was concluded that supplementation of pig diets with CLA and EPA/DHA resulted in the inclusion and sterication of these human health-related long chain fatty acids in pork, even being molecules not synthesized de novo in pork adipose tissue.

Keywords: DHA/EPA, CLA, Pig-fat

Selenium in muscular, renal, hepatic, cardiac and blood tissues of sheep supplemented with sodium selenite and seleno-methionine

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The objective of this work was to study selenium deposition in different organs of sheep supplemented in 2 chemical forms: sodium selenite and seleno-methionine. Cannulas were inserted in the duodene and rumen sections in 20 animals (30 kg, 6 mo). The lambs were fed for 15 d with diets supplemented with 0.1 ppm selenium. After this time, 2 10-animal batches were supplemented with 0.3 p.m. Se: (T1) as sodium selenite, and (T2) as seleno-methionine. A control group was left without selenium supplementation. Treatments were administered

directly to the rumen cannula, during the 10 d of adaptation and 5 d of sampling. Blood samples were extracted from the jugular vein; at the end of the study time, animals were slaughtered, samples taken from the skeletal muscle, heart, liver and kidney, and kept at -20°C until analysis. Mean comparisons were carried out by the least significant difference method. Differences in selenium concentration among the studied organs were analyzed by t-student tests at ($P \leq 0.05$). The results showed that after 5 d supplementation blood selenium increased 2-fold ($P \leq 0.01$) for both sodium selenite and seleno-methionine. However, after 15 d supplementation, selenium in blood showed no significant difference as compared with the fifth day in the same tissue, but concentrations dramatically increased in other organs. The highest selenium concentration was observed in the striated muscle, followed by liver, kidney and heart ($P \leq 0.05$). This can be explained by the fact that supplements are first detected in blood; later, selenium concentration in blood remained constant and this element finds other pathways for deposition, such as the striated muscle and liver. Due to the lower commercial cost of sodium selenite and having selenium the same deposition for both chemical forms it was concluded that, to improve selenium concentration in meat and viscera aimed for human consumption, sodium selenite is recommended.

Keywords: Sodium selenite, Seleno-methionine, Rumen

Effects of postmortem calcium chloride injection on meat quality traits of steaks from cattle fed with zilpaterol hydrochloride

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Two experiments were conducted to determine the effects of Zilpaterol hydrochloride supplementation (ZH; 6.8 g/ton on a 90% DM basis for 30 d) and calcium chloride injection (CaCl_2 200 mM at 5% wt/wt at 72 h postmortem) on palatability traits (Exp. 1) and shelf-life (Exp. 2) of beef strip loin steaks. USDA Select strip loins were obtained from control (non-ZH-fed) and ZH-fed cattle carcasses (Exp. 1 = 40; Exp. 2 = 20) and right and left sides were selected alternatively to serve as a control (non-injected) or CaCl_2 -injected and immediately vacuum packaged for storage at 2°C . For Exp. 1, at 7 d postmortem strip loins were portioned into steaks, vacuum packaged and aged until 28 d for Warner-Bratzler shear force values (WBSF; 7, 14, 21, and 28 d) and trained sensory analysis (14 and 21 d). For Exp. 2, treatments were evaluated at 7, 14, and 21 d postmortem using color analysis (trained panelist and Hunter L^* , a^* , b^*), metmyoglobin reducing activity (MRA) and lipid oxidation (TBARS) on steaks which were PVC-overwrapped and display for 3 d at 3°C in each postmortem time. Results from experiment 1 indicate both feeding groups and injection treatments diminished their WBSF values as days of postmortem aging increased; however, WBSF values for ZH-fed steaks were greater than non-ZH-fed steaks ($P < 0.05$), and CaCl_2 -injected steaks had lower WBSF values than non-injected steaks ($P < 0.05$) during all postmortem aging periods. Trained panelists gave a lower tenderness score to ZH-fed steaks than non-ZH-fed steaks at 14 d and 21 d. Contrary, the injection of CaCl_2 improved ($P < 0.05$) tenderness scores and flavor intensity, but with trend to be slight off-flavor (metallic) compared with non-injected steaks at 21 d. Results from experiment 2 indicate ZH-fed steaks showed better initial red color and more stable red color during retail display than non-ZH-fed ($P < 0.05$); though there were no differences in discoloration over

aging ($P = 0.06$). Non-injected steaks had better initial color than injected steaks ($P = 0.005$). Nonetheless, at 14 d of aging, injected steaks started to be more discolored and exhibited less color stability than non-injected steaks ($P = 0.0001$). These results were in accordance with the instrumental color results. No differences in MRA values were noted between feeding groups ($P = 0.2$); while, injection treatments groups diminished their MRA values as days of postmortem aging increased, but CaCl_2 -injected steak exhibited greater reducing ability than their counterpart. No differences in TBARS values existed between feeding groups ($P < 0.05$); but, injected steaks showed an increment of lipid oxidation compared with non-injected steaks ($P = 0.05$; 0.439 vs. 0.336 mg/kg). Overall, the postmortem injection of CaCl_2 solution to either ZH-fed or non-ZH subprimals can improve beef steak tenderness; although can be detrimental effects on shelf-life when aging is extended beyond 14 d.

Keywords: Zilpaterol hydrochloride, Calcium chloride, Tenderness and shelf-life

Technological characteristics of pork burger as influenced by tiger nut milk liquid co-product

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Many efforts have been made to improve the safety, quality, stability and nutritional properties of burgers because consumer demand for fast food has been increasing rapidly in the recent years. The valued added products (intermediate food product) obtained from co-products is an interesting practice that can contribute to obtain more benefits to all food industries. Tiger nuts or chufas (*Cyperus esculentus*) are tubers mainly used to produce *Horchata de chufa* (tiger nuts milk), yielding a high quantity of co-products (solids and liquids). The tiger nut milk liquid co-product (TLC) could be used as an ingredient for the food industry. Its physicochemical properties allow its use as a substitute of water addition to foods. However, due to its high microbial load, it requires pasteurization prior to its addition to foods. TLC is also a valuable source of natural antioxidants (phenolic compounds). The objective of this work was to study the effect of the water formula replacement by TLC on the chemical and physicochemical characteristics of pork burgers. Three independent replicates of each batch were prepared. A simple traditional formulation was used to obtain a base batter as follows (percentages of non-meat ingredients are related to meat): 55% lean pork meat, 45% pork backfat, 18% (w/w) water (ice), 1.5% (w/w) sodium chloride, 0.2% white pepper. This mixture was divided into batches and TLC substituted water in the formulation of pork burgers. Chemical composition, physicochemical, and cooking characteristics of burgers were evaluated. TLC addition caused a decreased ($P < 0.05$) in water activity (from 0.991 to 0.978). No differences ($P > 0.05$) were observed in pH, moisture, fat, protein and ash content among in the raw burger. Cooking yield, fat and moisture retention, diameter reduction and thickness increase were measured to determine the influence of adding TLC on pork burger formulations. Results showed that formulation with TLC added had the highest cooking yield ($P < 0.05$; 82.29% vs. 90.73%), fat and moisture retention (83.99% and 69.17% vs. 88.62% and 83.40%) and thickness increase (10.20% vs. 13.90%); also was observed a smaller diameter reduction ($P < 0.05$; 15.49% vs. 12.97%) in the pork burger. TLC addition caused, in the cooked burger, a texture improvement; because hardness, gumminess and chewiness were lower ($P < 0.05$) in the samples with TLC (12.00 N; 2.43 N and 12.98 N mm, respectively) than in burger formulated with tap water (21.60 N; 5.18 N and 27.48 N mm, respectively). Cooked pork burgers

elaborated with TLC had better cooking characteristics (higher cooking yield, fat and moisture retention and thickness increase and lower diameter reduction) and improved its texture. Utilization of TLC, as a substitute of water, in the formulation of pork burgers appears to be a valuable alternative.

Keywords: Pork burger, Tiger nut, Technological properties

Shelf life of five meat products displayed under light-emitting diode or fluorescent lighting

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Light-emitting diode (LED) lighting used in retail display cases offers economical savings in energy use and generates less heat compared with fluorescent (FLS) lighting. This study compared the effects of LED and FLS lighting on visual and instrumental meat color and shelf-life properties of 5 meat products displayed in 2 Hussmann retail display cases set up with the same operational and temperature profiles so that lighting was the single variable. For each treatment, 24 enhanced pork loin chops, 36 beef loin steaks, 24 ground beef, 24 ground turkey, and 36 beef inside round steaks were used. Pork loin chops and beef loin steaks were received in mother bags containing 0.15% CO–0.10% O₂–25% CO₂–74.75% N₂. Beef inside round steaks were cut fresh from sub-primals before display. Ground turkey was displayed in high-oxygen (75% O₂ and 19% CO₂) modified atmosphere packaging (MAP) while the remaining products were displayed on foam trays with moisture absorbent pads and overwrapped with polyvinyl chloride film. Visual color, instrumental color, aerobic plate counts (APC), *Enterobacteriaceae* counts (EB), internal product temperatures, case temperatures and thiobarbituric acid reactive substances (TBARS) values were measured. As expected, visual color scores of the 5 meat products indicated color deterioration increased as display time increased. Beef loin steaks, ground beef, and the superficial portion of beef inside round steaks had less ($P < 0.05$) visual discoloration under LED lighting than FLS. For instrumental color, pork loin chops under LED lighting had higher ($P < 0.05$) L* values. The superficial and deep portions of beef inside round steaks were slightly ($P < 0.05$) more intense red under LED lighting. For all other products, no differences ($P > 0.05$) were found for a* values or saturation indices. Lighting type had no effect ($P > 0.05$) on APC or EB populations except for pork loin chops which had an interaction between lighting type and day of display for APC populations. At the end of display, chops under LED lighting had lower APC populations than FLS. As expected, APC populations increased as display time increased for pork loin chops, ground beef, ground turkey, and beef inside round steaks. APC populations for beef loin steaks did not change ($P > 0.05$) during display, however display life was limited due to initial postmortem age. EB populations increased ($P < 0.05$) for pork loin chops, ground beef and ground turkey as display time increased. The internal temperature of all products, except beef loin steaks, was lower ($P < 0.05$) in the LED case. Compared with the LED case, FLS case temperatures were higher ($P < 0.05$) by 0.56 to 1.11 °C over the duration of the study. Pork loin chops, ground turkey, and beef inside round steaks had higher ($P < 0.05$) TBARS values under LED lighting, but lighting type did not affect ($P > 0.05$) TBARS of beef loin steaks or ground beef. LED lighting results in lower display case temperatures, lower internal product temperatures, and extended color life; however, lipid oxidation was increased in some cuts under LED lighting.

Keywords: Lighting, Color, Shelf life

Effect of dietary selenium supplementation on color shelf-life of beef Psoas major steaks from maturing heifers

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The color stability of beef during retail display is muscle-specific. Psoas major (PM) is an economically important muscle which is color-labile. Dietary supplementation of anti-oxidants can be utilized to retard meat discoloration during retail display. Therefore, the objective of this study was to evaluate the effect of dietary supplementation of different dietary selenium (Se) sources on meat color quality attributes of PM steaks in growing/maturing beef heifers individually fed to gain 0.5 kg/d. Twenty-eight Angus-cross heifers were assigned to 4 Se treatments ($n = 7$) for 226 d and throughout an 8-week harvest period. The basal diet contained 0.08 mg Se/day. Mineral supplements provided no Se (control, CON), 3 mg Se/day as inorganic (sodium selenite, ISe), organic (Sel-Plex, OSe), or 50/50 ISe/OSe (MIX). Heifers were humanely harvested at the University of Kentucky Meat Laboratory with treatments equally distributed over days of kill. After 24-h storage at 4 °C, PM muscle was excised from each carcass, fabricated into 6 1.5-cm steaks, and assigned to 0, 5, and 9 storage days. PM steaks were placed on styrofoam trays, over-wrapped with polyvinyl chloride film, and stored under constant, cool white fluorescent lighting (1300 lx) at 4 °C. Instrumental color (CIE L*, a*, b*, Hue, Chroma, R630/580) were measured with a Hunterlab LabScan XE colorimeter. In addition, metmyoglobin reducing activity (MRA), lipid oxidation (TBARS), and pH was determined on the respective storage days. Data were analyzed using ANOVA and mean separation procedures of the general linear model and the differences among means were detected at the 5% level using the least significant difference test. There was no effect ($P > 0.05$) of Se supplementation on L*, a*, or b*, Hue, Chroma, R630/580, MRA, TBARS, and pH of PM steaks during 9 d of simulated retail display. However, a* and b* values, Hue, Chroma, R630/580, and MRA decreased linearly by day ($P < 0.05$) in all dietary treatments during storage, indicating surface discoloration. On the other hand, TBARS increased ($P < 0.05$) progressively with storage days in PM steaks. Our results suggested that addition of 3 mg/d of Se to a basal diet which contained 0.08 mg Se/d to maturing beef heifers gaining 0.5 kg/d did not influence meat color-stability or lipid oxidation of PM steaks.

Keywords: Dietary selenium, Psoas major, Meat color

Fresh pork properties of pigs fed ractopamine hydrochloride and immunocastrated boars

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The objective of this study was to compare fresh pork properties among sex condition, and diets with and without ractopamine hydrochloride (RAC). Sixty animals (Agrocetes PIC–AGPIC 337 sires × CB 22 dams) from a commercial farm were grouped in females (FE, $n = 20$), physically castrated (PC, $n = 20$) and immunocastrated male pigs (IM, $n = 20$), fed or not with RAC (7.5 mg/kg, Ractosuín, Ourofino Agrobusiness) for the final 21 d before slaughter. The animals were separated in 6 treatments with 10 pigs for each combination of dietary and sex. The boars designated to be immunocastrated received 2 doses of vaccine according to

recommendation (Improvac, Pfizer Animal Health). After chilling, carcass pH_{24 h} was determined in the *M. semimembranosus* (SM) using a Meat pHmeter (Hanna, Model H199163). Pork loin was deboned, and the *M. longissimus dorsi* (LD) were evaluated for objective color ($L^*a^*b^*$) using a Minolta Chromameter (CR-400; Konica Minolta Sensing, Inc.). For drip loss, LD samples (80 to 100 g) were placed in a netting and suspended in an inflated bag for 48 h storage period at 4 °C. LD was sliced into a 2.54-cm-thick weighed and cooked on a clamshell style grill to an internal temperature of 72 °C, thus samples were reweighed to determine cooking loss which was expressed as a percentage of the initial sample weight. Texture was determined using the 3 mm thick Warner-Bratzler shear force (WBSF) attachment to the TAXT2i Texture Analyzer. The experiment was carried out as a factorial (2 × 3) arrangement with RAC diet (0 and 7.5 mg/kg) and sex condition (FE, PC and IM). Data were analyzed by ANOVA using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC) with a model including RAC, sex, and their interactions. Least squares means were separated by the PDIFF, and statistical differences were declared at $P \leq 0.05$ level. There was no RAC × sex ($P > 0.05$) interaction for any of the pork properties studied. RAC did not influence the pH_{24 h} values of the SM ($P > 0.05$). The pH_{24 h} was higher ($P \leq 0.05$) in FE (5.60) than PC and IM (5.43) pigs. RAC supplementation did not affect ($P > 0.05$) objective color. Longissimus muscle from PC presented higher a^* mean values (6.46, $P \leq 0.05$) than FE (5.59, $P \leq 0.05$), but both do not differ from IM (6.33, $P > 0.05$). Drip loss was not affected by either RAC treatment or animal sex ($P > 0.05$). Animal sex condition did not affect cooking loss and WBSF ($P > 0.05$). LD from RAC fed pigs presented higher ($P < 0.01$) cooking loss and WBSF means (23.83% and 3.42 kgf) than control (20.14% and 2.91 kgf). Animal sex condition had no important impact on fresh pork properties in this research. Immunocastrated males did not differ from physically castrated males. The addition of RAC on diet of finishing pigs increased cooking loss and toughness of pork.

Keywords: Ractopamine, Fresh pork properties, Immunocastration

Low-fat wet distillers grains influence beef quality

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Feeding wet distillers grains plus solubles to cattle increases polyunsaturated fatty acids (PUFA) within the lean, which are susceptible to oxidation and compromise shelf life. This study was conducted to determine if a feeding diet containing low-fat wet distillers grains without solubles (LFWDG) would also compromise beef quality. Forty-five (15 per dietary treatment) USDA strip loins (*M. longissimus lumborum*) were analyzed for fatty acid profile and color changes during a 7 d retail display period. Dietary treatments included LFWDG (4.72% fat; fed at 35% DM), traditional wet distillers grains with solubles (TWDGS; 6.91% fat; fed at 35% DM) and a corn-based control diet. The absence of solubles in the LFWDG diet meant that more DG were fed with this diet than with the TWDGS diet. Four days after simulated retail display, samples from cattle fed LFWDG had more oxidation than cattle fed TWDGS or control diets. After 5 d, steaks from cattle fed LFWDG were less red in color (lower a^*) and had more visual discoloration than other treatments ($P < 0.0001$ and $P < 0.05$, respectively). The L^* and b^* readings were not significantly different ($P > 0.05$). Samples from cattle fed LFWDG had approximately 10% more PUFA than samples from cattle fed TWDGS (4.86% vs. 4.46%, respectively; $P = 0.08$). There was no difference in saturated fatty acids or mono-unsaturated fatty acids among the treatments ($P = 0.19$, 0.79, respectively). Steaks from cattle fed diets containing WDG (with or without S) had lower percentages

($P < 0.05$) of 15:0, 16:0, 17:0 and 17:1 ($n = 7$) and higher percentages ($P < 0.05$) of 18:1 *trans*, 18:1Δ14, 18:2 *trans*, 18:3 ($n = 3$) and 20:3 ($n = 6$) than cattle fed the corn control diet. Steaks from the LFWDG diet had a larger percentage of 18:2 ($n = 6$) than the steaks from TWDGS, which had more than the control diet ($P < 0.0001$). For fatty acids 18:2 *cis* 9 *trans* 11 and 20:0, samples from cattle fed LFWDG were similar with the samples from cattle fed TWDGS and TWDGS were similar to the samples from the control diet ($P = 0.02$ and 0.05, respectively). These data suggest fatty acids contained within the distillers grains are partially protected from biohydrogenation during digestion, while fatty acids in the soluble fraction are more readily hydrogenated in the rumen. Consequently, diets formulated with LFWDG tend to stimulate more rapid discoloration compared with TWDGS and corn-based control diet.

Keywords: Beef quality, Wet distillers grains, Fatty acid profile

The use of calcium lactate to improve quality in beef round muscles in high-oxygen modified atmosphere packaging

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The purpose of this study was to examine the effect of calcium lactate on tenderness of beef round muscles stored in high-oxygen modified atmosphere packaging (HiOX) (80% O₂/20% CO₂). HiOX packaging has been shown to increase the toughness of some meat products. It was hypothesized that calcium lactate could limit this negative effect of HiOX packaging by serving as an activator of proteolysis and an antioxidant. Ten beef steers were harvested; at 24 h postmortem the deep *semimembranosus* (DSM) (inner 1/4 of the muscle), superficial *semimembranosus* (SSM) (outer 1/4 of the muscle), *semitendinosus*, and *adductor* in the round were removed. Each round was randomly assigned to either vacuum (VAC) or HiOX packaging. Each muscle was divided into 3 equal sections and randomly assigned one of 3 treatments: water injected control (CON), 3 mM sodium tripolyphosphate injected control (STP), and 200 mM calcium lactate injection, followed by a 20 min rest, and then injection with 3 mM phosphate (CAL). Because of its smaller size, the *adductor* was cut into 2 sections, CAL and STP. Steaks (2.54 cm) were then cut and vacuum packaged. After 9 d of storage, steaks assigned to HiOX were repackaged according to assigned treatment were displayed for 7 d under white light at 1 °C. At the end of storage (1, 9, or 16 d storage) star probe measurement of instrumental tenderness, sensory tenderness (d 16 storage only), and troponin-T and desmin degradation (30 kDa) were determined for each steak. Titin degradation was determined in the *semitendinosus*. At 16 d storage, CAL improved ($P < 0.05$) sensory tenderness in the HiOX DSM steaks compared with CON and STP steaks. CAL did not improve tenderness of HiOX SSM at 16 d storage. Sensory tenderness was increased ($P < 0.05$) in CAL treated VAC SSM compared with CON. At 9 d storage both CAL DSM and SSM had lower ($P < 0.05$) star probe values than CON or STP groups. Star probe at 16 d storage was decreased in CAL VAC *semitendinosus* while all other steaks injected with CAL showed no difference in star probe at 16 d storage. CAL tended to increase ($P = 0.063$) troponin-T degradation in the DSM at 9 d storage, while no effect of CAL on troponin-T degradation was observed in the SSM. No treatment differences were observed in titin degradation in the *semitendinosus*. There was a tendency ($P = 0.08$) for CAL to increase degradation of titin compared with STP treated *semitendinosus* cuts stored 1 d. Desmin degradation increased in 9 d CAL DSM steaks while no difference was observed in the SSM, *semitendinosus*, or *adductor*. Treatment with CAL resulted in increased

desmin degradation compared with STP in steaks from the *adductor* stored 9 d. Proteolysis and sensory data indicated CAL may improve tenderness, particularly in the DSM, by increasing proteolysis.

Keywords: Calcium lactate, Beef round, Quality

Impact of hydrochloric/citric acid blend as a pre-grinding intervention on ground beef instrumental color characteristics

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Since ground beef processing involves mixing and grinding of beef trim from various animals, the possibility of recontamination pose a risk in the final ground beef product. Therefore application of pre-grinding antimicrobial interventions can be beneficial to enhance microbial safety of ground beef. However, it is important to understand the impact of pre-grinding interventions on ground beef color properties. Hence, this study was focused on evaluating the instrumental color properties of ground beef processed with trim subjected to novel hydrochloric/citric acid based pre-grinding treatments. Inoculated (*Escherichia coli* and *salmonella* Typhimurium, 107 cfu/ml) beef trimmings (5 lb/treatment/replicate) were vacuum tumbled for 20 s with 500 mL of selected antimicrobial treatments (replicates = 3). The treatments involved 15% hydrochloric/citric acid blend (Citrilow, CIT) alone or CIT followed by 4% sodium metasilicate (CITNMS), 0.4% cetylpyridinium chloride (CITCPC), 10% trisodium phosphate (CITTSP) or water (CITW). The un-treated un-inoculated (CON) and inoculated (INCON) controls and treated beef trimmings were ground twice and 200 g from each treatment were placed on individual plastic foam trays with absorbent pads. The packages were over wrapped with polyvinyl chloride film and stored under simulated retail conditions (4 °C). Subsequently, the samples were evaluated for CIE L*, a* and b* values on d 0, 1, 2, 3, 4 and 5 of display using illuminant A/10° observer. On d 0 of display, CITTSP ground beef was more red ($P < 0.05$) compared with INCON and CON samples. CITTSP and CITNMS treatments maintained a similar redness ($P > 0.05$) compared with INCON and CON, respectively on d 1 through 5 of display. On d 0 of display, the hue angle of CITTSP and CITNMS treated ground beef were lower ($P < 0.05$), indicating more redness in color than the rest of the treatments. Further, these treatments continued to maintain a lower hue angle compared with CIT, CITCPC or CITW treatments. Similarly, CITTSP and CITNMS treated samples had more ($P < 0.05$) vivid color compared with all the treatments on d 0 and had similar vivid color to CON and INCON on d 2, 3 and 4 of display. Additionally, the oxymyoglobin proportions (630 nm/580 nm ratio) were highest ($P < 0.05$) in CITTSP compared with all the treatments on d 1 and 2 of display. The ground beef samples were lighter ($P < 0.05$) and more yellowish ($P < 0.05$) on d 0 compared with other days of display. There was no significant ($P > 0.05$) difference in L* during d 1 through 5 of display, however, the intensity of b* reduced ($P < 0.05$) with the time. Findings from this study indicate that use of hydrochloric/citric acid blend along with trisodium phosphate or sodium metasilicate may improve the ground beef redness and extend shelf-life. Therefore, the antimicrobial properties of these agents be may used as potential multiple pre-grinding interventions to enhance ground beef safety without adverse effects on ground beef color.

Keywords: Ground beef, Pre-grinding intervention, Instrumental color

The effects of freeze and thaw rates on retail display and purge loss for beef subprimals

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To evaluate handling methods for frozen beef subprimals, the effects of freezing and thawing rates on retail shelf life and percent purge loss were compared with that of fresh-never-frozen product. There were 6 treatments: fresh-never-frozen 14-day aged (14D), fresh-never-frozen 21-day aged (21D), blast frozen-fast thawed (BFFT), blast frozen-slow thawed (BFST), conventionally frozen-fast thawed (CFFT), and conventionally frozen-slow thawed (CFST). Three subprimal cuts—ribeye rolls, strip loins, and sirloins were utilized with 3 replications of 5 samples per treatment ($n = 270$). Blast freezing occurred by placing spacers between the boxes of meat on pallets at -28 °C with high air velocity while conventional freezing occurred with pallets stacked and placed in a -28 °C freezer with minimal air flow. Fast thawing (internal temperature of -2 °C) occurred by immersion in a circulating water bath (< 12 °C) for 21 h and slow thawing occurred over a 2 week period on tables at 0 °C. Thawed subprimals were weighed before cutting steaks from the *longissimus thoracis* (LT), *longissimus lumborum* (LL), and *gluteus medius* (GM). Steaks were weighed individually, packaged in oxygen-permeable film, and placed in retail display under continuous lighting at 2 °C for 8 d. Color measurements and discoloration scores were obtained daily and steaks were weighed at the end of display to calculate retail and total purge loss. Discoloration data were analyzed for the time at which a steak reached 40% discoloration. Numerically, steaks from the 14D fresh-never-frozen treatment always had the best color stability (discoloration scores and a^* -redness-values). All LL and LT steaks had approximately 4 d to 40% discoloration. All frozen treatments for the LL and GM steaks were equal or superior in color stability to 21D fresh steaks, except for the CFST LL steaks, which discolored more rapidly. For all subprimals, purge loss during storage/thawing was significantly higher for the slow thawed subprimals ($P < 0.0001$). Fast thawed subprimals were equal or superior to 14D and 21D fresh subprimals ($P < 0.0001$) in storage/thawing purge, likely a result of thawing to subfreezing temperatures. Conversely, during retail display, the greatest purge loss occurred in fast thawed treatments ($P < 0.0001$). Overall, total purge loss (moisture loss during storage/thawing and retail display) was about 5% higher for slow thawed LT and GM compared with 14D product and about 1.8% higher for LL. These data indicate that frozen-thawed beef subprimals are comparable to fresh-never-frozen subprimals in color stability during the first 4 d of retail display. However, total purge loss was increased for slow thawed subprimals. Freezing rate had minimal effects on retail quality.

Keywords: Beef, Freeze, Thaw

Tenderness and nutrient differences of beef from different genotypes

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The objective of this study was to determine tenderness and nutrient composition differences of beef from different genotypes (Angus, Angus × Piedmontese crosses, and Piedmontese). The genotypes had zero (0 C), one (1 C) or 2 (2 C) copies of the myostatin gene with base pair deletions which causes muscle hypertrophy ($n = 19, 28, 12$, respectively, for steers and 25, 26, and 9 for heifers). All animals were individually fed the same diet. Steers were fed for 190 d and heifers were fed for 114 d. At 3 d post mortem, carcass grading

factors were determined on all carcasses. Composite samples for nutrient analyses (proximate, lipid and mineral content) were created from 6 *longissimus dorsi* (LD) steaks and 6 *semitendinosus* (ST) steaks per genotype for steers. Steaks were trimmed to 1/8th inch of fat before nutrient analyses were conducted. Steaks from both muscles for all carcasses (steers and heifers) were aged for 14 d and Warner-Bratzler shear force values (WBS) were measured. All steaks were cooked on table top grills to 71 °C. The steaks wrapped in oxygen-permeable film and placed in a 4 °C cooler for 24 h. Six cores (1.27-cm diameter) were removed from each steak, parallel with the muscle fiber orientation using a 1.2-cm diameter coring bit. The 0 C samples had significantly more marbling, greater fat thicknesses and smaller ribeye areas ($P<0.05$) than the 1 C which had significantly more marbling and fat thicknesses with smaller ribeye areas ($P<0.05$) than the 2 C samples. Steaks from the 0 C heifers (LD and ST) and ST steaks from the 0 C steers had higher ($P<0.05$) WBS than steaks from the 2 C heifers and steers. Steaks from cattle with 1 C were intermediate in WBS. The steer LD steaks from 2 C animals had higher ($P<0.05$) WBS, by 0.4 kg, than LD steaks from 0 C steers. Moisture and protein levels were higher, with lower fat content and total calories in the 2 C samples when compared with the 0 C and 1 C samples. The 2 C samples had a lower saturated fat and a lower percent of trans and monounsaturated fatty acids than 0 C and 1 C samples. The 0 C and 1 C samples had lower levels of poly-unsaturated fatty acids. The mineral content was comparable between all 3 genotypes. Overall, the samples from the 2 C had the lowest marbling scores and were still comparable to 0 C samples for WBS. The 2 C samples were also higher in protein content and lower in fat content. Genotypes with 2 copies of the myostatin gene were generally leaner and more tender than those with 0 or 1 copy.

Keywords: Myostatin, Warner-Bratzler shear force, Nutrient analysis

Effects of antioxidant application and retail display on sensory, shelf life and oxidative stability of beef striploin steaks

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Antioxidant utilization is one of the primary mechanisms of quality stability and enhancement in many foods including processed meats. This research was aimed at evaluating the potential case life extension of beef strip-loin steaks applied with 2 approved antioxidant formulations: organic citric acid (CIT) 0.3% solution and synthetic butylated hydroxyanisole/butylated hydroxytoluene combination (SYN) 0.08% solution. Comparisons were made to a control treatment (CON) application of deionized water. Wholesale strip-loins (IMPS # 180; $n=32$) were obtained from a commercial harvesting facility and selected within a criteria for both quality grade (Low Choice) and yield grade (YG 2.8–3.2) guidelines to minimize strip-loin variation. Strip-loins were vacuum-packaged and stored at 2 °C. At postmortem d 14, 21 and 28 strip-loins were removed from vacuum packages and fabricated into 2.54-cm thick steaks. Steaks ($n=63$) were randomly assigned to one of 3 groups (CON, CIT and SYN) to achieve ($n=21$) samples/treatment. After treatment was applied utilizing a customized belt line and atomization cabinet, steaks were over-wrapped with polyvinyl chloride film, and placed in retail coffin style display case to simulate retail display conditions for a 5 d period. Visual and objective color was evaluated daily while sensory and TBA samples were removed during display days (DD) 1, 3 and 5. Treatment had effect on both visual and objective lean color especially DD 3–5. There were no effects of treatment on any sensory attributes when data was analyzed ($P>0.05$). SYN treatment maintained lean color of strip-loin steaks ($P<0.05$) while CON and CIT

exhibited additional discoloration in DD 4 and 5 when compared with SYN within all postmortem aging periods. CON and CIT also contained additional browning in DD 3–5 ($P<0.05$). SYN steaks exhibited higher a^* values through DD periods ($P<0.05$) when compared with either CON or CIT. SYN steaks exhibited higher oxymyoglobin level ($P=0.03$) and reduced metmyoglobin levels ($P<0.05$) throughout DD within all postmortem aging periods. Hue values were at higher level ($P<0.05$) for CON and CIT when compared with SYN through DD 1–5. CON and CIT exhibited increased TBA values on DD 1, 3 and 5 when compared with SYN steaks ($P<0.05$). Results from this study indicate that SYN antioxidant application to strip-loin steaks prolongs retail display shelf life by maintaining color and reducing rate of lipid oxidation without any negative sensory attributes.

Keywords: Antioxidant, Strip loin, Sensory

Effects of different meat sources and cooking methods on the physicochemical and textural characteristics of low-fat sausages

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Processed meats are required to meet the consumer preferences and healthiness. Various researches have been performed to develop the low-fat meat products as healthier foods. This study was performed to investigate the effects of different raw meat sources (beef vs pork) and cooking methods (boiling vs smoking) on the physicochemical and textural properties of low-fat sausages (LFS). Frozen imported beef rounds and fresh domestic pork hams alone or in combination (1:1) were mixed to manufacture the LFS with different cooking methods. Data were compared with beef and pork meats alone or in combination to identify the optimal conditions for LFS. Since all data did not show significant interactions between 2 factors, data were pooled. The fresh pork ham meats alone or in combination with frozen beef round enhanced the cooking loss, most textural properties, and sensory texture and overall acceptance of LFS, as compared with those of LFS with frozen beef round alone. In addition, the LFS containing beef round alone had darker color and more crumble texture than those of pork alone or in combined with beef round. On the other hand, boiling was beneficial to have improved product yields, while the boiling method had less preference in sensory flavor than those of oven smoking. In conclusion, the combination of fresh pork ham and frozen beef round meats at 1:1 ratio was acceptable and frozen imported beef could be used the potential possibility to replace the pork hams as a meat source.

Keywords: Low-fat sausages, Meat sources and cooking methods, Physicochemical and textural properties

Shelf life extension, organoleptic variation, and pathogenic reduction of noni-treated beef patties

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Noni (*Morinda citrifolia*) has long been used as a homeopathic remedy for ailments, recently there has been much research conducted to learn more of the antioxidant, immune stimulating, and antimicrobial properties of noni. Research has shown that incorporation of antioxidants can enhance color stability; also claims have been made concerning the antimicrobial effects of noni. Course ground beef (85% lean) was mixed by weight with 0, 2, 4, and 6% noni pulp, ground through a 9.5 mm plate, and

formed into 113 g patties. Patties were packaged and placed in simulated retail display (4 °C and 1600 lx lighting) for 5 d. No fewer than 8 experienced panelists evaluated the patties daily to determine visual color scores of total color, worst point color, and percent discoloration. Instrumental color was evaluated daily using a Hunter Miniscan to determine L* (lightness), a* (redness), and b* (yellowness). TBARS assays (lipid oxidation) were conducted on d 1, 3, and 5 of display. Beef patties, either cooked to 71 °C and were served warm for conventional panels; or cooked to 71 °C, chilled overnight and were warmed to 71 °C for warmed over flavor panels. Patties were evaluated by a trained taste panel to determine beef flavor juiciness, off flavor, as well as warmed over flavor. Inhibition of *Escherichia coli* O157:H7, *Salmonella* spp., and non-O157 Shiga Toxin producing *Escherichia coli* were determined with a zone of inhibition test amid noni (juice, puree, and pulp) solutions, using either tryptic soy agar or plate count agar. Pure noni solutions alone, for pulp were: 50, 75, and 100%; for puree were 2, 4, 6, 8, 10, 50, 75, and 100%; and for juice were 3, 5, 7, 10, 25, 50, 75, and 100%. Scores for total color, worst point color, and percent discoloration indicated that the panelists perceived the noni-incorporated patties as redder and less discolored than controls. Instrumental values also indicated that the noni patties were redder (greater a*) and yellower (greater b*) throughout display ($P < 0.01$). Similarly, analysis of TBARS assays showed oxidative rancidity was decreased with noni incorporation during display ($P < 0.05$). In both fresh and warmed over flavor taste panels, panelists perceived less beef flavor and more intense off flavor as the percentage of noni increased ($P < 0.05$). Freshly cooked patties decreased in mouth feel scores with increased noni percentage ($P < 0.05$); but patties with 2% noni pulp were perceived as the juiciest ($P < 0.05$). Microbial analysis indicated there was no true antimicrobial activity in solutions of noni used. Noni juice at 100% resulted in slight inhibition of *E. coli* O157:H7, *Salmonella*, and non-O157 STEC. Noni puree at greater than 75% and noni pulp at greater than 50% resulted in slight inhibition to *Salmonella* and non-O157 STEC. Results from these studies showed that while noni may increase shelf life, there needs to be more research done to increase consumer acceptability and provide pathogenic reduction for noni-treated ground beef.

Keywords: Noni, Color stability, Antimicrobial

The shelf life and stability of traditionally packaged ground beef of three lean formulations as influenced by storage at –1.7 or 2.3 °C for up to 28 days prior to retail display

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Approximately 50% of ground beef storage life is lost at the accepted storage temperature of 2 °C. However, the effect of lean formulation, and its interaction with storage parameters, on the shelf life of traditionally packaged ground beef is widely unknown. This research aimed to characterize the effects of cold storage temperature (–1.7 or 2.3 °C) and storage length on the shelf life properties of ground beef of 3 formulations. Coarse ground beef chubs of 3 lean:fat formulations (73:27, 81:19 and 91:9) were divided into 2 storage temperatures (–1.7 or 2.3 °C) and stored in darkness for 7, 14, 21 or 28 d. At each 7 d interval, one chub per storage temperature and formulation was removed from storage, finely ground, portioned, and packaged on expanded polystyrene trays wrapped in polyvinyl chloride (PVC) film. Packages were placed in retail cases maintained at 0–2 °C for 24 h. Samples were obtained before packaging and after 24 h of lighted retail display. Samples were analyzed using a variety of subjective and objective measurements, including: thiobarbituric acid (TBA) analysis, trained panel sensory, instrumental color (L*, a*, b*), and non-pathogenic aerobic plate counts (APC). Instrumental L* values increased ($P < 0.05$) in higher fat formulations; however, no differences in initial or

24 h redness (a*) were noted between lean formulations. Trained panelists were unable to detect differences in initial color due to storage length or temperature, but did indicate differences due to lean formulation ($P = 0.0083$). In accordance with saturation values, panelists indicated increased discoloration and reduced color stability as storage length increased ($P < 0.05$). Panelists indicated that ground beef stored at 2.3 °C was more discolored and less stable after 24 h than product stored at –1.7 °C. Aerobic plate counts increased as storage increased from 7 to 28 d and were higher for ground beef stored at 2.3 °C ($P < 0.05$). Initial TBA values increased as the storage period progressed through 21 d. However, a decline in initial TBA values after 28 d was noted for all formulations, except 73:27 ground beef stored at 2.3 °C. Overall, these data indicate initial physical and biochemical indicators of color stability and shelf life were dependent primarily on lean composition; however, the effects of storage temperature and length were notable after 24 h of display and indicated declining shelf-life at a higher storage temperature (2.3 °C). Regardless, ground beef stored for 21 or 28 d before display had compromised shelf life.

Keywords: Composition, Ground beef, Shelf life

Cookery method impacts on instrumental cooked color and tenderness of goat loin chops

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It appears the demand for goat products is rising as slaughter numbers continue to increase on a yearly basis, whereby spurring a further need for research applications on goats and goat meat products. The objectives of this study were to evaluate the effects of cookery method on instrumental tenderness and internal cooked color of goat loin chops. Fresh loins were vacuum-packaged and aged at 2 °C in the absence of light for 7 d. Following the aging period, loins were frozen at –10 °C until fabrication could be completed. Frozen loins (n = 32) were cut into 2.54 cm-thick chops using a BIRO Bandsaw, individually identified, and randomly assigned to cookery applications (Convection Oven-BLOD, Gas-Fired Open Hearth Grill-CHAR, and Electric Giddle-GRID). After cutting, chops were vacuum packaged and stored at –10 °C until analysis could be conducted. Prior to cooking, chops were thawed for 24 h at 2 °C, removed from the vacuum package, weighed to determine pre-cooked weight, and cooked to an internal temperature of 71 °C. Instrumental cooked color (L*, a*, b*, and 630:580 red to brown) was conducted using a Hunter MiniScan XE, and instrumental tenderness was assessed using an Instron with the Warner-Bratzler Shear Force attachment. Data were analyzed as a completely randomized design with the mixed model procedure of SAS (SAS Inc., Cary, NC). For all variables, least squares means were generated, and when significant ($P < 0.05$) F-values were observed, least squares means were separated with the PDIF option. Cookery method resulted in a slight improvement ($P < 0.05$) in WBSF as chops cooked on the CHAR grill received lower values than chops prepared with the BLOD and GRID methods. Lightness (L*) values appeared darker when chops were cooked using a method such as the BLOD and forced-air convection ($P < 0.05$) than chops using a direct or radiant heat methods such as the CHAR or GRID. However, redness (a*) values were greater ($P < 0.05$) for chops cooked with radiant heat methods than those in direct contact (GRID) or convection heating (BLOD) methods. As a measure of the change in the internal cooked color from red to brown which occurs during the cooking process the reflectance ratio (630:580) was calculated from instrumental spectral measurements. Red to brown values were greater ($P < 0.05$) for chops cooked using the CHAR method than convection (BLOD) or direct heat methods (GRID). Results from

this study indicate that cookery methods and heat transfer through the product can impart differences in the instrumental assessment of internal cooked color and tenderness measurements.

Keywords: Goat, Cookery method, Shear force

Association of pro-melanin concentrating hormone genotype with Warner-Bratzler shear force of beef longissimus dorsi

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Beef cattle from 2 independent studies were obtained from feedyards in the Texas panhandle (n = 352) and southern Idaho (n = 542) to assess the association of pro-melanin concentrating hormone (PMCH) genotype with beef tenderness. Tissue samples were collected from each animal at each site to determine which PMCH allele they expressed (Texas; AA–49.43%, AT–21.59%, TT–28.98%; Idaho; AA–65.87%, AT–29.34%, TT–4.80). Twenty 4 h after harvest, carcass attributes were evaluated and *longissimus dorsi* muscle samples were collected. Three steaks were allocated from each carcass and aged for 7, 14, or 21 d postmortem. Warner-Bratzler shear force measurements were determined for each steak. The Idaho site had greater percentages of steaks below tenderness thresholds of 4.0 and 4.6 kg compared with the Texas site. Study site (Adj R² = 0.30, Root MSE = 0.736), cooking loss (Adj R² = 0.29, Root MSE = 0.744), block (Adj R² = 0.23, Root MSE = 0.771), marbling score (Adj R² = 0.17, Root MSE = 0.802), presence or absence of zilpaterol hydrochloride in the feeding ration (Adj R² = 0.15, Root MSE = 0.813), calculated empty body fat (Adj R² = 0.12, Root MSE = 0.833), fat thickness (Adj R² = 0.08, Root MSE = 0.848), calculated yield grade (Adj R² = 0.04, Root MSE = 0.862), number of PMCH T alleles present (Adj R² = 0.03, Root MSE = 0.866), and hot carcass weight (Adj R² = 0.01, Root MSE = 0.876) accounted for variation in Warner-Bratzler shear force value. Predicting objective tenderness with pre-harvest knowledge of presence or absence of zilpaterol hydrochloride in the feeding ration and number of T alleles present accounted for 18% of the variation (Adj R² = 0.18, Root MSE = 0.80) in Warner-Bratzler shear force. When predicting objective tenderness with pre- and post-harvest knowledge, presence or absence of zilpaterol hydrochloride in the feeding ration, number of T alleles present, fat thickness, LM area, and marbling score accounted for 31% of the variation (Adj R² = 0.31, Root MSE = 0.73) in Warner-Bratzler shear force. When predicting objective tenderness with pre- and post-harvest factors and cooking factors, presence or absence of zilpaterol hydrochloride in the feeding ration, number of T alleles present, LM area, percentage of empty body fat, marbling score, and cooking loss accounted for 44% of the variation (Adj R² = 0.44, Root MSE = 0.66) in Warner-Bratzler shear force. Using only knowledge of the number of T alleles present was used to quantify variation in cooking loss (Adj R² = 0.18, Root MSE = 0.035), percentage of empty body fat (Adj R² = 0.06, Root MSE = 2.969), marbling score (Adj R² = 0.05, Root MSE = 8.755), fat thickness (Adj R² = 0.04, Root MSE = 0.495), calculated yield grade (Adj R² = 0.04, Root MSE = 0.744), hot carcass weight (Adj R² = 0.02, Root MSE = 33.190), and lean color score (Adj R² = 0.01, Root MSE = 0.555). PMCH genotype explained a small portion of the variation in Warner-Bratzler shear force value and appeared to be a more useful indicator before harvest.

Keywords: Pro-melanin concentrating hormone, Warner-Bratzler shear force, Beef cattle

The effects of freezing and thawing rates on tenderness and sensory quality of beef subprimals

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To evaluate handling methods for frozen beef subprimals, the effects of freezing and thawing rates on tenderness and sensory properties were evaluated. There were 6 treatments: fresh–never–frozen 14 d aged, fresh–never–frozen 21 d aged, blast frozen–fast thawed, blast frozen–slow thawed, conventionally frozen–fast thawed, and conventionally frozen–slow thawed. Three subprimal cuts—ribeye rolls, strip loins, and sirloins—were utilized with 3 replications of 5 samples per treatment (n = 270). Blast freezing occurred by placing spacers between the boxes of meat on pallets at –28 °C with high air velocity while conventional freezing occurred with pallets stacked and placed in a –28 °C freezer with minimal air movement. Fast thawing of subprimals (internal temperature of –2 °C) occurred by immersion in a circulating water bath (<12 °C) for 21 h and slow thawing of subprimals occurred over a 2 week period set on tables at 0 °C. Purge loss was measured after thawing—before cutting. Steaks were cut from the *longissimus thoracis* (LT), *longissimus lumborum* (LL), and *gluteus medius* (GM) (2.5 cm thick) for Warner-Bratzler shear force (WBS) and trained sensory evaluation. Sensory samples were rated for tenderness, juiciness, connective tissue, and off-flavor after cooking to 71 °C. Slow thawed subprimals had the greatest amount of purge loss (P < 0.001) in the LT, LL and GM. Fast thawed subprimals were equal or superior in purge loss to fresh–never–frozen 14 and 21 d aged subprimals (P < 0.0001) in the LT, LL and GM. For all steaks, frozen treatments were equal or superior in WBS to fresh–never–frozen 14 and 21 d aged steaks. For LL and LT steaks, slow thawed steaks were equal or superior in WBS when compared with fast thawed steaks (P = 0.01). There were no differences in WBS among the GM steaks (P = 0.08). There were no differences in sensory tenderness within the LL, LT, and GM (P > 0.05). There were no significant differences in juiciness in the LL and GM (P > 0.05). The LT fresh–never–frozen 14 and 21 d aged product was juicier than the frozen product (P = 0.001). There was no difference in connective tissue in the LT or GM (P > 0.05). A greater amount of connective tissue was detected in the slow thawed LL compared with the fast thawed LL (P = 0.02). There were no differences in off-flavor in the LT and LL (P > 0.05). Conventionally frozen–fast thawed steaks had the strongest prevalence of off-flavor (P = 0.02) in the GM. Overall, when thaw rates are properly managed, tenderness and sensory attributes will be comparable to fresh product.

Keywords: Beef, Freezing method, Thawing method

Effect of modified distillers grains with solubles and crude glycerin inclusion in beef cattle finishing diets on shear force and moisture loss of beef strip steaks

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The objective of this study was to evaluate the inclusion of modified distillers grains with solubles (MDGS) and crude glycerin in beef finishing diets, on quality characteristics of fresh strip steaks. Crossbred steers and heifers (n = 48) were assigned randomly to one of 4 treatment groups and fed individually using a Calan gate feeding system. Treatments were arranged in a 2 × 2 factorial design as follows: traditional steam flaked corn diet with no MDGS or glycerin

inclusion (CON); CON with 35% MDGS substitution (MDGS); CON with 10% glycerin added (GLY); and both 35% MDGS and 10% glycerin added (MDGS/GLY). Crude glycerin and MDGS inclusion was in the place of steam flaked corn in the MDGS, GLY, and MDGS/GLY treatments. When cattle reached a mean weight of 590 kg, they were humanely harvested at a commercial abattoir in 2 groups. Strip loins were removed from the right side of each carcass 48 h post mortem, vacuum packaged, and transported refrigerated to the University of Minnesota Meats Laboratory. Strip loins were weighed in packaging and after packaging removal to calculate vacuum purge loss percentage. Two 2.54-cm steaks were cut serially from the anterior end of each strip loin for further analysis. Steaks were weighed, suspended for 24 h at refrigerated temperature and isolated atmosphere, and then re-weighed to calculate drip loss percentage. For shear force analysis, steaks were weighed, cooked to an internal temperature of 71 °C, tempered to room temperature, and re-weighed to calculate cooking loss percentage. Six cores were taken from each steak and evaluated for Warner–Bratzler shear force. Treatment did not affect vacuum purge loss ($P=0.75$) or cooking loss ($P=0.40$). Treatment did not affect drip loss, however did show a trend ($P=0.06$) with MDGS having higher values than all other treatments. Treatment did not affect Warner–Bratzler shear force values ($P=0.94$), however shear force was numerically lower for MDGS. These results suggest that the inclusion of MDGS and crude glycerin in beef cattle finishing diets did not negatively impact meat quality characteristics as they pertain to shear force and moisture loss of beef strip steaks.

Keywords: Beef, Glycerin, MDGS

Effect of modified distillers grains with solubles and crude glycerin inclusion in beef cattle finishing diets on shelf life and sensory characteristics of beef strip steaks and ground beef

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The objective of this study was to evaluate the inclusion of modified distiller grains with solubles (MDGS) and crude glycerin in beef finishing diets, on quality characteristics of fresh strip steaks and ground beef. Crossbred steers and heifers ($n=48$) were assigned randomly to one of 4 treatment groups and fed individually using a Calan gate feeding system. Treatments were arranged in a 2×2 factorial design as follows: traditional steam flaked corn diet with no MDGS or glycerin (CON); CON with 35% MDGS substitution (MDGS); CON with 10% glycerin added (GLY); and both 35% MDGS and 10% glycerin added (MDGS/GLY). Crude glycerin and MDGS inclusion was in the place of steam flaked corn in the MDGS, GLY, and MDGS/GLY treatments. At a mean weight of 590 kg, cattle were humanely harvested at a commercial abattoir in 2 groups. Strip loins and shoulder clods were removed from the right side of each carcass 48 h post mortem, vacuum packaged, and stored refrigerated. Five 2.54-cm steaks were cut serially from the anterior end of each strip loin for further analysis. Shoulder clods were ground individually, twice through a 0.375-cm grinder plate. Two strip steaks and 0.5 kg of ground beef from each animal were placed on separate trays with PVC overwrap and stored at 4 °C under cool white fluorescent lighting for 7 d. Objective color values (L^* , a^* , and b^*) were taken at 6 locations on each package with a Minolta CR-310. Subjective color scores (lean color, surface discoloration and overall appearance) were evaluated by an 8 member trained panel. Steaks for consumer sensory evaluation were cooked to an internal temperature of 71 °C, cut into 1 cm \times 1 cm \times 1 cm cubes, and served to an untrained consumer panel

(118 panelists). Each panelist was given 2 steak cubes per treatment and asked to evaluate overall liking, flavor liking, texture liking, toughness, juiciness, and off flavor. There were no differences between treatments for L^* , a^* , or b^* values ($P=0.40$, 0.90 and 0.64, respectively) for strip steaks. Additionally, lean color, surface discoloration, and overall appearance of strip steaks was not affected by treatment ($P=0.76$, 0.97 and 0.95, respectively) for all 7 d of the trial. Treatment did not affect ground beef L^* , a^* , or b^* values ($P=0.06$, 0.09 and 0.89, respectively) or subjective lean color, surface discoloration, and overall appearance ($P=0.87$, 0.89, and 0.35, respectively). CON and MDGS had higher values for consumer overall liking and texture liking of strip steaks ($P=0.02$ and 0.002 respectively). Treatment did not affect flavor liking, however did show a trend ($P=0.08$) with MDGS having higher values than MDGS/GLY. MDGS/GLY had higher toughness values than CON and MDGS, but not GLY ($P<0.001$) and CON had the highest values for juiciness ($P<0.001$). Results indicate that the addition of MDGS and crude glycerin in beef finishing diets did not negatively affect color stability of strip steaks and ground beef, but may impact sensory characteristics of beef strip steaks.

Keywords: Beef, Glycerin, MDGS

Dietary antioxidants have little effect on the tenderness decline and protein oxidation that occur during retail display of beef in high oxygen modified atmospheric packages

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This study was conducted to evaluate the effects of feeding dietary antioxidants (Agrado Plus; AG, which contains ethoxyquin and tertiary butyl hydroquinone) to beef cattle on protein oxidation and tenderness of beef subjected to retail display in high oxygen (80% O₂: 20% CO₂) modified atmospheric packages (HiO₂-MAP). Crossbred (British \times Continental) steers ($n=467$) were fed dry-rolled corn-based finishing diets containing 0 (corn) or 30% wet distillers grains plus solubles (WDGS) supplemented with AG (0 or 150 ppm for the last 145–160 d). After 48 h of postmortem chilling, USDA Choice beef short loins from 20 carcasses per dietary treatment were collected and aged a total of 8 and 29 d at 0 ± 2 °C. Each *m. longissimus lumborum* was cut into 6 steaks. Two steaks (for 0 d protein oxidation and shear force samples) were vacuum-packaged and stored at -20 °C. Two other steaks were packaged in oxygen-permeable film on Styrofoam trays (PVC-OW) or in HiO₂-MAP, and displayed for 7 d under simulated retail display conditions for shear force testing. Two additional steaks were cut into halves, packaged as either PVC-OW or HiO₂-MAP, and retail displayed either 4 or 7 d for protein oxidation measurements. Tenderness of steaks was determined by the Warner–Bratzler Shear Force (WBSF) test and protein oxidation was evaluated by measuring carbonyls and free thiol (sulfhydryl) contents. More carbonyls and fewer sulfhydryls indicate more protein oxidation of steaks. Dietary treatment significantly ($P=0.02$) affected WBSF. Steaks from AG fed cattle had significantly ($P=0.04$) higher WBSF value compared with steaks from cattle fed non-AG supplemented diets; steaks from corn plus AG fed cattle the highest WBSF values ($P=0.02$). The PVC-OW steaks were more tender than HiO₂-MAP steaks after retail display ($P<0.0001$). During retail display, steaks in PVC-OW packaging improved in tenderness ($P<0.01$) while those in HiO₂-MAP decreased in tenderness ($P<0.0001$). This effect was more dramatic in steaks aged 29 d compared with those aged 8 d ($P=0.03$). Aging significantly increased steak tenderness ($P<0.05$). Carbonyls of

29 d aged steaks increased during retail display irrespective to the dietary treatment ($P < 0.05$). Eight and 29 d aged steaks from corn + AG diets had significantly more carbonyls compared with steaks from non-AG supplemented corn diets. Steaks in HiO_2 -MAP had more carbonyls than PVC-OW steaks ($P = 0.03$). Sulfhydryls decreased during aging and during retail display ($P < 0.05$). During retail display, steaks from cattle fed non-AG supplemented diets had fewer ($P < 0.05$) sulfhydryls than steaks from AG-fed cattle. Steaks in HiO_2 -MAP tended to have less sulfhydryls compared with steaks in PVC-OW ($P = 0.09$) during retail display. Overall results indicate that longer aging and HiO_2 -MAP of steaks cause more protein oxidation (higher carbonyls and lower sulfhydryls) and reduced tenderness during retail display. Moreover, feeding Agrado Plus tends to decrease tenderness and increase protein oxidation (fewer free thiols) during retail display.

Keywords: Beef tenderness, Protein oxidation, Antioxidant

Effects of phase-feeding beef tallow on quality characteristics of bacon from growing-finishing pigs fed dried distillers grains with solubles

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Crossbred pigs ($n = 216$) were used to test the effects of phase-feeding beef tallow (BT) on quality characteristics of bacon from growing-finishing swine. Pigs were blocked by initial BW (26 ± 5.3 kg) and gender before allotment to pens (6 pigs/pen), and pens (6 pens/block) were allotted randomly to 1 of 6 dietary treatments. Dietary treatments consisted of: a negative control (NC) devoid of BT for all phases; a positive control (PC) with 5% BT for all phases; or treatments including 5% BT during phases 1 and 2 (BT12), during phases 1, 2, and 3 (BT123), during phases 3, 4, and 5 (BT345), or during phases 4 and 5 (BT45). All dietary treatments were formulated with 30% dried distillers grains with solubles (DDGS) during phases 1, 2, and 3, 15% DDGS during phase 4, and no DDGS during phase 5. Pigs were slaughtered at a commercial pork packing plant at an average BW of 124.1 kg. Bellies were identified with each pig's identification number before transportation to a commercial bacon-manufacturing plant, where weights were recorded during each step of curing and thermal processing. Then, bellies were sliced, and USDA-certified No. 1 slices were collected, individually boxed, and transported under refrigeration to the University of Arkansas for cooking characteristics and sensory panel evaluations. Upon arrival at the abattoir, sliced bacon from the center of each belly was identified, vacuum packaged, and stored at -20°C . Bacon for cooking characteristic evaluation was thawed at 1°C for 24 h before evaluation. Instrumental color (L^* , a^* , and b^*) values of the bacon fat were determined with a Hunter Miniscan XE. Bacon was cooked in a commercial convection oven (preheated to 204.4°C) for 9 min, blotted dry and precooked and cooked weights were used to calculate cooking loss percentage. A 6.0-cm section of bacon was removed from the center of the slices, and each section was sheared once through with a 6-blade Allo-Kramer shear force device attached to an Instron Universal Testing Machine. Shear force values of the cooked bacon were determined from a mean of 4 sections. For each taste panel session ($n = 18$), 12 slices of bacon from one pig from each of the dietary treatments was used (72 slices/panel). Bacon was thawed for 48 h at 1°C , striated randomly across 8 racks (9 slices/rack), and cooked in convection ovens (preheated to 218.3°C) for 17 min. Each panelist received 6 slices (approximately 7.5 cm length) of bacon in random order. Panelists were provided unsalted saltine crackers, drinking water, and apple juice or apple slices to cleanse their palates between samples. Yield of

commercially-processed bacon (pumped belly yield, smoked belly yield, and the percentage of number 1 bacon slices) was not ($P \geq 0.14$) affected by the dietary treatments. There was no ($P \geq 0.23$) effect of BT inclusion on color (L^* , a^* , and b^* values) of the bacon fat, cook loss percentage, or Allo-Kramer shear force. Traits evaluated by the sensory panel (initial crispiness, bacon flavor intensity, saltiness, sustained chewiness, oiliness, and off flavor intensity) were not ($P \geq 0.55$) affected by the dietary treatments. Results of this study indicated that phase-feeding BT to pigs fed diets formulated with DDGS had no impact on quality characteristics of bacon.

Keywords: Bacon, Phase feeding, Beef tallow

Light-emitting diode effects on color stability of frozen beef and refrigerated cured pork

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Since light-emitting diodes are designed to not emit UV light, they have the potential to improve color stability by reducing photooxidation associated with traditional lighting. To test this hypothesis, fresh Black Angus (USDA Select, $n = 4$, 21 d PM, 5.55 average pH, experiment 1) strip loins were cut into steaks (3.8-cm thick) with each steak assigned to one of 4 bloom conditions (Air, 100% Oxygen) and lighting displays (fluorescent; light emitting diode, LED; 1076 lx). Steaks were bloomed (24 h, 2°C), then vacuumed packaged and frozen (-15°C , dark, 6 d) before being continuously displayed (-11°C). Color stability was assessed instrumentally at 12 h intervals. Vacuum packaged pork loins ($n = 4$, 2°C , 19 d PM, 5.62 average pH, experiment 2) were cut in half. Sections were injected with a solution of NaCl (1%) and sodium nitrite (50 or 150 ppm). Loins were tumbled (18 RPM, 2 h, 2°C), cured overnight, stuffed (fibrous casings) and then smokehouse processed (71°C internal). Chops (2.5 cm thick) were removed and vacuum packaged. Packages were inflated with 1% oxygen and displayed (2°C). Color measurements were taken immediately after packaging and at 4, 8 and 12 h on d 1. After d 1, measurements were taken in 12 h increments. Individual loins represented the experimental unit. Results were analyzed using Proc Mixed of SAS to determine main and interaction effects. When significance ($P < 0.05$) was found in the models, means were separated by pairwise comparisons using the PDIF option of SAS. For experiment 1, colorimeter (CIE a^* , chroma C^*) and reflectance spectrophotometric measurements (%R630nm divided by %R580nm, higher ratio, more intense red) did not document a difference ($P > 0.05$) between lighting types on air-bloomed steaks for these redness indicators. However, LED lighting improved color stability in oxygen-bloomed steaks as determined by higher ($P < 0.05$) values (more intense red) along with less metmyoglobin (MMb) accumulation (%R572nm divided by %R525nm) compared with oxygen-bloomed steaks under fluorescent lighting. LED lighting also resulted in less ($P < 0.05$) MMb compared with fluorescent lighting in air-bloomed steaks. Color deteriorated over display time regardless of bloom condition or lighting. Although LED lighting did extend beef color stability of oxygen-bloomed steaks the extension was not as long as that of typical unfrozen beef. For experiment 2, there were no differences ($P > 0.05$) in CIE a^* , Chroma C^* or nitrosylhemochrome (NITHEME) concentration in the cured pork between the 2 different display lights. There were no differences ($P > 0.05$) in NITHEME concentration in the pork loins cured with 50 and 150 ppm sodium nitrite. Differences ($P < 0.05$) were found between 50 and 150 ppm sodium nitrite chops in CIE a^* (6.71 versus 7.13, respectively; standard error, 0.169) and chroma C^* (7.33 versus 7.75, respectively; standard error, 0.175). With increasing display time, means of CIE a^* ,

Chroma C* and NITHEME generally decreased. No interactions ($P>0.05$) were found. LED lighting does not appear to offer retailers any increase in color stability as frozen beef color rapidly deteriorated similar to beef under fluorescent lighting. In addition, in low-oxygen compromised or poorly packaged cured pork, LED lighting did not demonstrate any color stability benefits.

Keywords: Light-emitting diodes, Color stability, Fresh beef and cured pork

Evaluation of the influence of genetic markers on meat quality

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Genetic variation in meat animals can have a profound effect on meat quality. One hundred twenty market hogs were slaughtered at approximate weight of 123.0 kg and then chilled overnight. Carcass data were collected including: hot carcass weight, cold carcass weight, first rib fat thickness, last rib fat thickness, last lumbar fat thickness, average back fat thickness, tenth rib fat thickness, and loin eye area. Meat quality was determined by measuring: Japanese color score, marbling score, loin firmness score, Minolta color score (L^* , a^* and b^*), pH, drip loss, Warner-Bratzler shear force, and cooking loss. Alleles in Protein kinase, AMP-activated γ -3 subunit (PRKAG3) have been reported to have economic importance to the meat industry, because of its effects on glycogen content and related meat quality traits. The γ -peptide, encoded by PRKAG3 gene, is one of the 3 variants for the γ -regulatory subunit of AMP-activated protein kinase (AMPK). AMPK plays a key role in the regulation of energy homeostasis. DNA was isolated from muscle and genotyping of the PRKAG3-1199V polymorphisms was performed using PCR-RFLP. The allelic frequency of the 199I is known to be associated with lower glycogen content and favorable meat quality was 0.3. The frequency for the homozygous genotype for the 199I allele was 0.11. Associations between the genotypes of PRKAG3-1199V and meat and carcass quality were evaluated by a mixed model procedure using PRKAG3 genotype and treatment as fixed effects with the pen as a random effect. Hot carcass weight (HCW) was found to be greater in the animals with the genotype VV ($P<0.05$) with 95.28 kg compared with the genotypes of IV (93.16 kg) and II (92.57 kg). Cold carcass weight (CCW) was greater in the animals with the genotype VV ($P<0.05$) with 94.60 kg compared with the genotypes of IV (92.57 kg) and II (91.83 kg). Drip loss (II: 2.58 g, IV: 2.67 g, and VV: 3.32 g) and Warner-Bratzler shear force (II: 2.47 kg, IV: 2.48 kg, and VV: 2.74 kg) was associated with an increase with the genotype of VV ($P<0.05$). As expected, the genotype 199I/199I was associated with the highest pH, and lowest Minolta L^* and b^* score but the differences between the genotypes were not significant due to the limited size of the data set. Results were of a similar trend to previous reports on the affects DNA markers on meat quality. Further investigation and understanding of the gene and its selection may improve pork quality.

Keywords: PRKAG3, AMPK, Genotype

Retail display and microbiological characteristics of dry-aged beef

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USDA Choice and Select beef top sirloin butts ($n=60$) and beef bone-in strip loins ($n=60$) were aged for 21 d, 28 d or 35 d and then fabricated into 2.54 cm steaks ($n=360$). Steaks were displayed in a cooler (0–2 °C) under constant lighting for 5 d to simulate a retail case environment. A trained panel evaluated lean color, fat color, and off-

odor. Aerobic plate counts (APC), lactic acid bacteria (LAB), and yeast and mold (YM) counts were obtained from samples taken from each wholesale cut as well as subsequent steaks. USDA quality grade did not ($P>0.05$) influence subprimal shrinkage during the aging period. Wet-aged subprimals had less ($P<0.0001$) shrinkage than dry-aged subprimals. Dry-aged subprimal shrinkage increased ($P=0.0026$) between 21 d and 28 d. No difference ($P>0.05$) was seen in subprimal shrinkage between 28 d and 35 d of dry aging, or 21 d, 28 d, and 35 d of wet aging. As expected, wet-aged subprimals had less ($P<0.05$) shrinkage than dry-aged subprimals. Dry-aged sirloin subprimals exhibited greater ($P<0.05$) shrinkage than dry-aged loin subprimals. The lowest aerobic plate counts and lactic acid bacteria counts for subprimals were seen at 21 d. Higher APC and LAB counts were found at 0, 28, and 35 d ($P<0.05$). Yeast and mold counts were highest for subprimals at 28 and 35 d. The YM counts for 21 d subprimals were similar to 28 d subprimal counts ($P>0.05$), but significantly less than 35 d subprimal YM counts ($P=0.0104$). The lowest YM counts were observed at 0 d, and were different ($P<0.05$) from all other YM counts at 21, 28 and 35 d of aging. APCs did not differ ($P>0.05$) between wet- and dry-aged subprimals. As expected, wet-aged subprimals had higher ($P<0.0001$) LAB counts than did dry-aged subprimals. However, YM counts were higher ($P<0.0003$) for dry-aged subprimals when compared with wet-aged subprimals. Lower ($P<0.05$) surface lean discoloration scores were found from steaks from dry-aged vs. wet-aged, top sirloin vs. top loin, and Select vs. Choice. Degree of surface lean discoloration increased as aging period and retail shelf day increased ($P<0.05$). Degree of fat discoloration was highest ($P<0.05$) for dry-aged steaks in comparison to wet-aged steaks, and top loin steaks compared with top sirloin steaks. Degree of fat discoloration did not differ ($P=0.2631$) between Choice steaks and Select steaks. As expected, degree of fat discoloration increased ($P<0.05$) as aging period increased. Also, it appeared that the occurrence of fat off-colors increased as aging period and retail steak shelf-life day increased. Top loin steaks and those steaks that were dry-aged exhibited more fat off-colors than did top sirloin steaks or those that had been wet-aged. There were no major differences in fat off-color between Choice steaks or Select steaks. Steak off-odor intensity increased ($P<0.05$) as retail shelf day increased, regardless of steak type or dry/wet aging treatment. A potential protocol for minimizing unappealing sensory attributes of aged steaks would be to shorten the aging period, followed by fewer days of display in the retail case. By reducing the aging period, retailers could also minimize yield loss; however, this may negatively affect desired flavor development and enhancement of the brown, roasted flavors associated with dry-aged beef.

Keywords: Beef, Dry aging, Shelf-life

Role of antioxidants in color and tenderness of beef steaks in high and low oxygen packages

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Pigment oxidation causes discoloration in beef during retail display. Protein oxidation reduces beef tenderness under high oxygen packaging conditions. These 2 studies were conducted to evaluate the effectiveness of various antioxidants on controlling discoloration and tenderness during retail display of beef under low or high oxygen conditions. Each study used steaks from 5 strip loins that were aged for 14 d. Steaks were held as untreated controls or dipped in one of 6 antioxidant solutions containing α -tocopherol (T), tertiary butyl hydroquinone (TBHQ), a commercial extract of Rosemary (Herbalox, Kalsec Inc., Kalamazoo, MI), or combinations of 2 of the antioxidants

(T and TBHQ; TBHQ and Herbalox; T and Herbalox). From each loin, 2 steaks per treatment (1 for tenderness; 1 for oxidation tests) were used. Preliminary tests were conducted to determine optimal concentrations and application methods. After treatment, steaks were packaged in modified atmosphere packages containing low levels of oxygen (2–5% O₂ LowOx-MAP) or high levels of oxygen (80% O₂/20% CO₂; HiOx-MAP). Color measurements (L*, a*, and b*) and discoloration scores (estimated percent discoloration) were obtained daily during a 7 d retail display period. Tenderness was measured by Warner-Bratzler shear force (WBS) at the beginning and the end of retail display on steaks cooked to 71 °C. There were no significant differences in WBS across all treatments for either experiment. Steaks packaged with the LowOx-MAP discolored at a more rapid rate than those packaged with HiOx-MAP. Under LowOx-MAP steaks treated with solutions containing TBHQ had significantly less ($P < 0.0001$) discoloration after 3 d of retail display than steaks treated with the other antioxidants. These differences were evident after 6 d for the HiOx-MAP study ($P < 0.0001$). Steak a* values decreased during retail display. This decline was more severe ($P < 0.0001$) for steaks dipped in solutions that did not contain TBHQ and packaged in LowOx-MAP. There were no differences in a* values among treatments using HiOx-MAP. Under modified atmosphere packaging, oxidation of myoglobin pigments is unrelated to beef tenderness. The antioxidant TBHQ was most effective in minimizing myoglobin oxidation during retail display.

Keywords: Beef tenderness, Antioxidant, Protein oxidation

Effects of Hydro-Lac inclusion pre-harvest on glycolytic potential and sensory attributes of beef

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The 2005 National Beef Quality Audit revealed that 1.9% of carcasses were categorized as dark cutters resulting in an estimated \$168 million loss to the industry due to poor retail display properties, shorter product shelf life and poor sensory attributes. While strategies to improve animal handling and management practices have reduced the incidence of dark cutters, cases remain, and new strategies to further reduce this quality defect are necessary. Hydro-Lac[®] (HL) is a patented, timed event nutrition (T.E.N) product, designed to provide essential nutrients, electrolytes, sugars, and other proprietary ingredients necessary to maintain fluid balance and performance in live cattle during periods of stress. However, the mechanisms by which HL may mediate the effects of stress on beef quality have not been evaluated. Therefore, the objective of this study was to determine the effects of HL on the incidence of dark cutting beef, glycolytic potential, and meat sensory attributes. Thirty-two (n=32) Holstein steers received HL supplementation for 2 d before slaughter and 32 (n=32) received no supplement to serve as the control (CON). Carcass data were recorded 48 h postmortem, and a 7.62 cm section of the *longissimus dorsi* (LD) was removed posterior to the ribbed surface. Samples were trimmed and further dissected into 2.54 cm steaks for Warner-Bratzler shear force (WBSF) analysis and 0.6 cm slices for evaluation of glycolytic potential and pH. Lean trimmings were pooled within treatment group, coarsely ground, mixed, finely ground, and formed into 114 g patties. Patties were retail overwrapped and evaluated at d 0, 2, 4, and 7 after grinding for subjective color analysis (lean color, percent discoloration, desirability), objective color analysis (Minolta L* and a*), taste panel sensory evaluation (juiciness, rancidity, beef flavor intensity, and off flavor) and lipid oxidation. No

significant differences were observed for carcass characteristics or WBSF, however HL samples were numerically lower in WBSF compared with CON samples ($P = 0.1192$). Although no carcasses were identified as dark cutters, HL samples revealed significantly higher glycolytic potential ($P = 0.0004$) and a trend for lower ultimate pH ($P = 0.0559$). Sensory panel evaluation of beef patties revealed no differences between CON and HL samples for lean color, percent discoloration, desirability, or beef flavor. However, CON samples showed a higher degree of rancidity ($P = 0.0274$) and detectable off-flavors ($P = 0.0152$, 0.0007 and < 0.001 for d 2, 4, and 7 respectively) compared with HL samples. No difference were observed for a*, however HL patties had significantly higher L* values ($P = 0.0052$, 0.0016, < 0.0001 , and 0.0002 for d 0, 2, 4, and 7 respectively). Additionally, lipid oxidation (TBARS) values were significantly higher ($P < 0.0001$) at d 2, 4, and 7 of retail storage in CON patties compared with HL patties. Collectively this study illustrates that HL inclusion in pre-harvest cattle diets increases the glycolytic potential of beef LD, reduces sensory evaluation of rancidity and detectable off-flavors and reduces lipid oxidation.

Keywords: Dark cutter, Glycolytic potential, Sensory panel

Effectiveness of oxygen barrier oven bags in low temperature cooking on reduction of warmed over flavor in beef roasts

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The objective of this study was to evaluate combinations of beef roasts cooked in commercially available cooking bags compared with open-roasting, fresh vs reheat, and different roast sizes to determine the most effective combination to prevent warmed-over-flavor (WOF). Reynolds oven bags (Reynolds Packaging Group, Richmond, VA) and Cryovac oxygen barrier bags (Cryovac Sealed Air Corp., Duncan, SC) and open-pan roasting comprised the bag treatment. Within each treatment clods (NAMPS 116) were portioned into 1.1 kg, 2.2 kg, and whole (7.3 kg). The roast size and bag treatment combinations were then designated to be evaluated as freshly cooked or reheated (cooking method). Six roasts of each type were cooked in a convection oven at 77 °C until an internal temperature of 71 °C was reached and held for one to 2 h. The roasts to be reheated were placed in refrigeration (4 °C), held for 72 h (as cooked, in a bag or open). A daily assignment of roast combinations was randomly determined before the beginning of the experiment. Reheated roasts were brought to an internal temperature of 69 °C. Both fresh and reheated roasts were presented to a trained sensory panel with no more than 8 samples evaluated at any session. A trained panel of 7 members evaluated 1.27 cm cubes for cardboardy, painty, brothy, salty, bitter, fatty, sweet, and other off-flavors on an 8 point hedonic scale as recommended by AMSA. The descriptors of cardboardy and painty were the indicators of WOF development. All of the means for the WOF descriptors were low as was consistency of responses. No sample received a unanimous nonzero response for any of the descriptors and all had means below 3 on the 8 point sensory scale. Panelists detected a significant WOF descriptor painty in the interaction of weight × bag ($P = 0.03$); painty intensity increased in open-pan roasts as the size increased, however painty in Reynolds bags decreased as roasts size increased. Panelists also found significant painty descriptor presence in the interaction of weight × cooking ($P = 0.05$), the painty intensity was more evident as size of the roasts increased. Cardboardy was significant for the interaction of bag × cooking ($P = 0.03$), responses showed reheated roasts were more cardboardy than the fresh, especially for open cooked roasts. Each roast was sampled and immediately frozen on dry-ice for

thiobarbituric acid-reactive substances (TBARS) analysis and reported as mg of malondialdehyde (MDA) per kg of meat. Differences in MDA were found in the interactions of weight×bag ($P<0.0001$), cooking×bag ($P=0.001$), cooking×weight ($P<0.0001$), and weight×bag×cooking ($P<0.0001$). All interactions appear to be due to an unexplained inordinately high MDA value for 2.2 kg fresh roasts in Reynolds and especially Cryovac bags. The 7.3 kg roasts had the lowest MDA values regardless of bag treatment or fresh vs reheat. Panelist WOF descriptor responses were inconsistent and oxidation products appeared difficult to produce using beef clods under this protocol. To prevent WOF in reheated beef roasts, a large size roast in a cooking bag is the most effective method.

Keywords: WOF, Beef, Cooking bags

The impact of post mortem aging on longissimus lumborum, gluteus medius, and semimembranosus muscles in cattle fed zilpaterol hydrochloride

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Past research has shown β -agonists such as zilpaterol hydrochloride (ZH) tend to increase Warner-Bratzler shear force (WBSF) values. The objective of this study was to examine the impact of aging on WBSF and sliced shear force (SSF) values of longissimus lumborum (LL), gluteus medius (GM), and semimembranosus (SM) muscles in cattle fed ZH. Black, English-type steers ($n=480$) were assigned to the following treatments: no ZH (CON) and zilpaterol hydrochloride (ZH), then blocked by weight. Seventy 2 carcasses were randomly selected per treatment, carcass data were recorded, and full loins and inside rounds were collected ($n=144$). Full loins were fabricated into strip loins and top butts. Five 2.54 cm steaks were collected from each muscle and assigned to an aging period (7, 14, 21, 28, and 35 d). Warner-Bratzler shear force was conducted on LL, GM, and SM steaks for all aging periods while SSF measurements were collected from 14 d and 21 d LL steaks only. Data were analyzed as a randomized complete block design using the MIXED procedures of SAS. The model statement included ZH and CON and the random statement included plant as the block. Least squares means were computed and separated ($P<0.05$) using the PDIF option of the MIXED procedure. Binomial proportion (frequency) data were analyzed using the GLMIX procedure of SAS with the same overall model described above, but without a random statement. Frequency data indicates that 74.3% of CON and 69.7% of ZH carcasses graded Choice or above ($P=0.26$). Cattle fed ZH were significantly ($P<0.05$) less tender than CON cattle for LL steaks across all aging periods. Slice shear force data also supports this difference in 14 d and 21 d steaks. At 14 d 100% of Choice or higher LL CON and ZH WBSF were values under 4.6 kg. Likewise, at 21 d and again at 35 d 100% of Select or lower LL ZH steaks tested less than 4.6 kg. Aging ZH LL steaks numerically reduced the WBSF value from 3.45 kg (7 d) to 2.85 kg (35 d) compared with CON LL steaks which were 2.84 kg at 7 d and 2.59 kg at 35 d. No significant differences between CON and ZH cattle were found in GM or SM steaks. However, GM 7 d ZH steaks (3.59 kg) did exhibit a tendency ($P=0.06$) to be less tender than CON steaks (3.33 kg). When aging GM steaks to 14 d, the tendencies between ZH (3.35 kg) and CON (3.28 kg) were eliminated ($P=0.62$). Continued aging of these GM steaks to 35 d removed any differences ($P=0.90$) between ZH and CON steaks (3.13 kg, 3.12 kg, respectively). Ultimately, aging ZH steaks removes any differences in tenderness. In addition, ZH steaks

numerically aged better than CON steaks for all 3 muscles. While mechanical differences in tenderness were found in LL steaks, aging to 21 d will likely remove any differences detectable by the consumer. The ZH treatment had no significant impact on the tenderness of GM or SM muscles, which also demonstrated numerical differences in regards to *post mortem* aging. Therefore, feeding ZH to cattle that are predisposed to being tender had no negative impact on the tenderness of LL, GM, and SM steaks if aged 21 d. Research on muscle fiber diameter, fiber type, and protein abundance may be beneficial to understanding why ZH decreases tenderness in cattle and second, ZH carcasses respond well to aging.

Keywords: Shear force, Zilpaterol hydrochloride, Beef

The effects of inclusion of various components of field peas in the finishing diets of Piedmontese x Angus heifers on growth and carcass characteristics

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The objective of this study was to determine the effects of various field pea components in finishing diets on growth and carcass traits in cattle. Piedmontese x Angus crossbred heifers ($n=126$) were blocked by weight and assigned by pen into 1 of 4 dietary treatments (CON=no field peas; WRL=15% of DM as dry rolled field peas (hulls + seed); HULL=15% of DM as field pea hulls; CHIP=15% of DM as field pea chips (seed only)). Heifers were fed in 16 identical pens with 4 pens per treatment. Feed intake per pen was recorded daily, and individual heifer weights were taken every 28 d. Heifers were fed for 120 d and slaughtered at a commercial processing facility on 2 dates. Carcass data was collected 48 h after chill by trained university personnel, and samples were taken from the longissimus thoracis, semimembranosus, biceps femoris, and suprapinatus of each carcass. Steaks (2.5-cm thick) were removed from each sample, vacuum packaged immediately, aged for 14 d and then frozen. Warner-Bratzler shear force (WBSF) was measured for each aged steak. Data were analyzed using the MIXED procedure of SAS. The model included treatment, block, and date-of-slaughter with pen serving as the random variable. The addition of various forms of field peas to the finishing diets of Piedmontese x Angus crossed heifers did not affect ADG ($P=0.4$), DMI ($P=0.97$), and G:F ($P=0.26$). The treatment did not affect HCW ($P=0.97$), 12th rib LM area ($P=0.52$), KPH ($P=0.41$), marbling ($P=0.76$), yield grade ($P=0.62$), and 12th rib fat ($P=0.16$). Dietary treatment did not affect the WBSF ($P>0.15$) of the longissimus thoracis, semimembranosus, biceps femoris, and suprapinatus steaks of each carcass. These data suggest that the addition of various components of field peas to finishing diets for 120 d did not affect growth performance and carcass characteristics of Piedmontese x Angus crossbred heifers.

Effect of kiwi fruit juice solution enhancement on color stability of beef semitendinosus steaks

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Beef color is an important quality attribute to consumers when making purchasing decisions from the retail case. Enhancement of lower valued cuts can be beneficial to consumers by increasing palatability, but has been shown to affect beef color stability. Marination with kiwi fruit enzyme, actinidin, has been shown to

increase tenderness yet limited research is available on its effect on beef color. The objective of this experiment was to determine the effects of varying levels of kiwi fruit juice enhancement on beef *semitendinosus* (ST) color stability. Fifty USDA Select, beef ST muscles were obtained from a commercial packing facility. Five days postmortem, ST muscles were randomly allotted to 5 treatments: control (non-enhanced; C), enhanced (water, salt, phosphates; E), and enhanced with a 1% (K1), 3% (K3), or 5% (K5) fresh kiwi fruit juice solution with a multi-needle injector to 110% of fresh weight, and tumbled under vacuum. Each ST muscle was vacuum packaged in a high barrier bag and aged for 7 d. One steak (2.54 cm) was fabricated from the medial portion of each ST muscle, placed on a styrofoam tray, polyvinyl chloride film overwrapped, and placed in a cooler (4 °C) under fluorescent lighting. Samples were measured daily over a 7 d period for objective and subjective color analysis. Objective color for L* (lightness), a* (redness), b*(yellowness) were taken using a Minolta Colorimeter, and subjective color analysis was conducted by trained panelists for visual color (1 = very bright red to 5 = very dark red) and discoloration (1 = 0% to 7 = 100% discoloration). A subsample was taken from each treatment for pH analysis. Data was analyzed as a completely randomized design using a general linear model procedure in SAS to analyze effects of treatment, day and treatment × day interaction. Interactions of treatment and day were not significant for L*, b*, or visual color, with only main effects found to differ. Enhancement with K5 significantly decreased L* values ($P < 0.05$) compared with all other treatments. C steaks had higher b* values ($P < 0.05$) and K5 steaks had lower b* values ($P < 0.05$) compared with all other treatments with no differences between E, K1, and K3 steaks. C and K1 steaks had lower visual color scores (brighter red) compared with E and K3 steaks, and K5 steaks had the highest visual color scores (dark red; $P < 0.05$). An interaction was observed for a* values; E steaks had a more rapid rate of decline in a* values and C steaks had the slowest rate of decline in a* values from 0 to 5 d ($P < 0.05$). However, by 7 d no differences were found for a* values between treatments ($P > 0.05$). Sensory discoloration was consistent across all treatments from 0 to 3 d. E steaks showed more discoloration at 4 and 5 d ($P < 0.05$) while C steaks showed the least sensory discoloration at 5 and 6 d ($P < 0.05$), however no differences were observed across all treatments by 7 d ($P < 0.05$). No pH differences were found between enhanced steaks; however C steaks had a lower pH ($P < 0.05$) than all other treatments. These data show kiwi enhancement had an effect on beef color; however, the effect was minimal, particularly in relation to E steaks.

Keywords: Beef color, Enhancement, Discoloration

Effect of storage in the presence of trona on pH, color, microbial load and lipid oxidation of ground beef

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Modified atmosphere packaging (MAP) is used to increase beef color stability and may affect lipid oxidation and microbial growth. Finding a proper blend of gases for MAP for a specific use is a current focus in the industry. Trona is an evaporated mineral and the primary source of sodium carbonate in the USA. Trona mineral releases carbon dioxide in the presence of moisture. Anecdotal reports have been made about prolonged shelf life of fresh ground beef when stored in the presence of trona mineral-containing packets, but this has not been verified in a formal study. This study was done to evaluate effects of trona packets on pH, color, microbial growth, thiobarbituric acid (TBA) values of ground beef under retail (1 °C) and home (4 °C) storage conditions. PVC-wrapped patties were held in 4 display

conditions: 1) walk-in cooler with 4 trona packets (66 g each) and intermittent fan-driven air circulation (simulated self-serve retail case); 2) walk-in cooler w/o trona packets, and with fan-circulated air; 3) closed polyethylene box (50 × 90 × 18 cm) with 1 trona packet and sealed with tape (no air circulation); 4) closed box, w/o trona, no air circulation. Total plate count (TPC), pH, Hunter color and TBA values were measured after 0, 2, 4 and 7 days of retail storage. After 4 days, some patties from all 4 retail storage conditions were placed into one of two home refrigerators with or without trona. The same analyses were performed after 1, 2 and 4 days of home storage (5, 6 and 8 days total storage time). Three independent replicates (different meat sources, different weeks) were performed for the entire experiment. No significant effects of retail storage were found with trona packets for color, pH, TPC or TBA values ($P > 0.5$). Exposure to trona for 2 days in home refrigerators slightly but significantly increased TBA values (0.4 and 0.5 for patties w/or w/o trona exposure, respectively). No other significant effect of trona was observed in home refrigerators. In conclusion, use of trona packets was not effective to enhance beef patty color stability or shelf life under the conditions used in this study.

Keywords: Meat color, Storage condition, Trona

Enhancement of beef *semitendinosus* with varying levels of kiwi fruit juice solution decreases shear force and increases collagen solubility of *semitendinosus* steaks

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Tenderness is an important issue to beef packers and retailers and has been established as the primary determinant of beef palatability. Variation in tenderness is due to differences in connective tissue content, sarcomere length, and postmortem proteolysis. Marination with kiwi fruit juice containing the enzyme actinidin has been shown to increase tenderness in beef, pork, and lamb muscles by increasing collagen solubility. The objective of this experiment was to determine the effects of enhancement on beef *semitendinosus* (ST) with varying levels of kiwi fruit juice on tenderness, moisture loss, and collagen solubility. Fifty beef ST muscles (USDA Select) were obtained from a commercial packing facility, transported to the South Dakota State University Meat Laboratory and stored at 2 °C until allotted to treatment. *Semitendinosus* muscles (n = 10) were randomly allotted to 1 of 5 treatments: a non-enhanced control, water enhanced containing water, salt and phosphate (pH = 9.06), enhanced with 1% fresh kiwi fruit juice solution containing water, salt and phosphate (pH = 8.80), 3% fresh kiwi fruit juice solution containing water, salt and phosphate (pH = 8.25) or 5% fresh kiwi fruit juice solution containing water, salt and phosphate (pH = 7.99). *Semitendinosus* muscles were enhanced to 110% of individual muscle weight using a multineedle injector. Following enhancement ST muscles were tumbled under vacuum to aid in the distribution of the solution throughout the muscle. Each ST muscle was vacuum packaged in a high barrier bag and aged for 7 d. Following the aging period purge loss was measured as the difference in the weight of the muscle in the bag and weight of the muscle plus the bag weight and divided by weight of the muscle. Two steaks (2.54 cm thick) were fabricated from the medial portion of each ST and used to determine Warner-Bratzler shear force, collagen solubility, and cook yield. *Semitendinosus* steaks were cooked using an electric clamshell grill (George Forman Indoor/Outdoor Grill) to 71 °C. Peak internal cooked temperature measurements were recorded for each steak using a hand-held thermometer. Purge loss was increased with enhancement ($P = 0.001$)

but was not affected by addition of kiwi juice to the enhancement solution ($P=0.79$). Warner-Bratzler shear force decreased linearly ($P<0.0001$) with enhancement and increasing levels of kiwi fruit juice. However, cook yield was not affected by enhancement ($P=0.49$) or enhancement with kiwi fruit juice ($P=0.24$). Soluble collagen increased linearly ($P<0.0001$) and insoluble collagen decreased linearly ($P<0.0001$) with enhancement and increasing levels of kiwi juice. These data show that kiwi fruit juice enhancement increases tenderness, collagen solubility and moisture loss during storage.

Keywords: Tenderness, Collagen, Enhancement

Improving tenderness of beef bottom round steaks with exogenous proteases and calcium chloride

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Tenderness is among the most important palatability traits of beef. Bottom round steaks are generally considered inferior in tenderness, yet juicy and flavorful. Therefore, improving tenderness of the bottom round should yield highly desirable beef steaks. Plant enzymes have long been used to improve meat tenderness by proteolysis of myofibrillar and collagenous proteins. Calcium chloride (CaCl_2) activates calpain proteases and thereby induces myofibrillar protein degradation. Our objective was to determine the effects of exogenous proteases, bromelain (BR) or actinidin from kiwi extract (KE), in the absence or presence of CaCl_2 , on Warner-Bratzler shear force (WBSF) of beef bottom round steaks. Outside rounds (flat; IMPS 171B) from USDA Select carcasses were procured a minimum of 14 d postmortem. The ischiatic heads were removed and bottom round flats were denuded and cut into 3 sections (proximal, middle, and distal). Treatments were randomized among sections, and a minimum of 4 sections per treatment were used. Exogenous enzymes or 2.2% CaCl_2 (w/v) were suspended in water and injected into product, using a 4 needle injector, to 105% of green product weight. Control samples were injected with water. Bromelain treatments included 0.05, 0.075, 0.1, 0.2, 0.3, 0.6% (w/v), and KE treatments were 0.1, 0.3, 0.5, 1.0, 2.0% (w/v). Product was vacuum-tumbled for 20 min, then packaged and aged for 7 d at 4 °C before fabrication into steaks. Steaks (2.54 cm-thick) were cut perpendicular to the muscle fiber orientation. Following a 20 min bloom time, color (CIE $L^*a^*b^*$) of the fresh cut muscle surface was measured. Steaks were weighed and then cooked on open-hearth broilers to an internal temperature of 71 °C. Steaks were then re-weighed to determine cooking loss, and allowed to cool to room temperature. Six cores (1.27 cm-diameter) were mechanically removed for WBSF determination. Preliminary experiments revealed that concentrations of BR above 0.1%, and concentrations of KE above 0.3% resulted in steaks with an undesirable texture, whereas exogenous enzyme treatments below these concentrations did not ($P>0.1$) reduce WBSF. Bottom round steaks treated with 0.1% BR, 0.3% KE, 2.2% CaCl_2 , or their combinations (KE + CaCl_2 and BR + CaCl_2) had lower ($P<0.01$) WBSF than control steaks. The magnitude of the treatment response was similar among treatments. Enzyme and CaCl_2 treatments did not affect cooking loss ($P=0.34$) or color ($P=0.29$) of beef bottom round steaks. In conclusion, BR, KE, and CaCl_2 effectively reduce WBSF of beef bottom round steaks, but the effects of exogenous proteases and CaCl_2 are not additive.

Keywords: Beef, Bottom round, Tenderness

Characterization of volatile flavor compounds identified from cooked beef steaks using headspace solid phase microextraction gas chromatography mass spectrometry and their relation to USDA quality grade

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Beef flavor is variable yet is the factor often shown to have greatest importance for consumer preference. Discoveries and improvements in the area of beef flavor are vital to the beef industry. Objectives of the study were to formulate and implement an analytical method for collection and analysis of beef volatile flavor compounds and to determine the association of USDA quality grade upon volatile beef flavor compounds. Volatile flavor compounds were collected from *Longissimus lumborum* (LD, $n=3$ per animal) steaks from 3 young beef animals of A maturity representing 5 USDA quality grades (Prime, Upper 2-thirds Choice, Low Choice, Select, and Standard). Head space solid phase microextraction (HS-SPME) was used to collect volatile compounds which were then analyzed by gas chromatography mass spectrometry (GC-MS). Among the volatile compounds collected and analyzed, 22 compounds previously shown to be associated with beef were identified by a mass spectral library and verified by comparison of target ions to those of authentic standards. The verified compounds were then quantified by an internal standard method (4-octanol). Among the 22 quantified compounds, 14 were selected ($P<0.30$) through univariate analyses for inclusion in a multivariate ANOVA model. Multivariate analysis indicated that 84.73% of the variability in the response variable (quality grade) was explained by the magnitude of volatile compounds. Compounds acetaldehyde, 2, 3-butanedione, 3-hydroxy-2-butanone, heptanal, phenylacetaldehyde, dimethyl sulfide, 2-butanone, dimethyl disulfide, 2, 5-dimethyl pyrazines, nonanal, butanal, 2-methyl butanal, hexanal, and octanal had the largest to smallest impacts. Magnitude of compounds may indicate which compounds are influenced most by quality grade. Correlations of volatile compounds within quality grade (ranked 1–5, with 1 = Prime and 5 = Standard) revealed that ketones, such as, 2, 3-butanedione (0.30), 2-butanone (0.34), 3-hydroxy-2-butanone (0.30), 2,5-dimethylpyrazine (0.32; a pyrazine), and nonanal (0.31; an aldehyde) were correlated with quality grade ($P<0.05$). Aldehydes and ketones are products of lipid thermal degradation. We hypothesize, therefore, the correlations observed were based on differences in thermal degradation mechanisms of lipids within beef steaks of lower USDA quality grades and the further development of pyrazines was due to the Maillard reaction. These findings indicate that the developed method of analysis has potential to aid in the understanding of beef flavor through the measurement of volatile aroma compounds. However, much future research is required to fully explain the mechanisms of beef flavor chemistry.

Keywords: Beef, Flavor, HS-SPME

Chemical characterization of grass- and grain-fed beef related to meat quality and flavor attributes

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There is currently much interest regarding forage-fed beef in the human diet, because of health benefits. Animal diet is important in determining sensory quality of meat. Some reports indicate a higher incidence of off-flavors in forage-finished beef. However, comparatively

is little known about the linkage between feeding regimens and their effect on specific compounds affecting beef flavor, oxidative stability, and antioxidant status. Thus, project aims were to evaluate beef quality as affected by grass- or grain feeding, and to correlate sensory attributes with specific flavor compounds. Cattle were finished for ~120 d exclusively on irrigated mixed grass/legume pasture (grass-fed), or an ad libitum ration of 60% corn silage, 30% flaked barley, and 10% chopped alfalfa hay (grain-fed). Animals (3/treatment) were harvested at 20–25 mo of age (318–360 kg carcass weight). Primal ribs were vacuum packaged and immediately frozen (-20°C) for later analysis (<6 mo postmortem). Sample analyses were conducted in triplicate for all chemical and color measurements except thiobarbituric acid assay (duplicates). Ribs from grain-fed animals had higher fat content (12.43%) than grass-fed animals (3.36%), as expected. Raw steaks from grass-fed animals were darker ($P=0.0004$), with less red ($P=0.0214$) and yellow hue ($P=0.0013$). Grass-fed beef had higher antioxidant capacity, associated with a lower degree of oxidation, i.e., lower TBA values ($P<0.05$), and higher level of polyunsaturated fatty acids ($P<0.05$), including conjugated linoleic acid ($P=0.0013$), with positive health attributes. Animal diet also influenced headspace volatiles of heated meat. Volatiles were collected by solid phase micro-extraction, and identified by gas chromatography/mass spectroscopy. Descriptive panel sensory evaluation (12 trained panelists) was done on cooked steaks (74°C internal temperature). Negative attributes such as barny, gamey, and grassy were higher in grass-fed beef ($P<0.05$), associated with higher levels of benzaldehyde, toluene, dimethyl sulfone, 3-heptanone, hexadecanoic acid methyl ester, and 2-ethyl-1-hexanol. Grain-fed beef steaks had higher ($P<0.05$) levels of hexanal, 1-octen-3-ol, 2,3-octandione, and 2,6-bis(1,1-dimethylethyl)-4-ethyl-phenol. This information will assist producers with product labeling and marketing, and help consumers make wise decisions about the role of meat in a healthy diet.

Keywords: PUFA, Volatiles, Grass-fed

Gender, fatness, muscling, and carcass weight influences on the cutability of yield grade 4 beef carcasses

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Carcass composition of yield grade (YG) 4 and 5 is a major non-conformity resulting in excess external fat and seam fat in carcass components. Cattle feeders, in an effort to maximize quality grade, have fed cattle to heavier weights and higher yield grades. Based on carcass composition and value difference of YG 4's, merchandising strategies for beef cuts with incorrect cutability endpoints were a major research need. This study was conducted to assess cutout and value differences in YG 4 beef carcasses by evaluating influences of gender, fatness, muscling, and weight, and determine optimum utilization of yield grade 4 carcasses by packers. USDA Choice, YG 4 carcasses ($n=60$) were selected according to gender: heifers ($n=20$) and steers ($n=40$); and weight groups: lightweight heifers (315.5 to 362.9 kg), lightweight steers (362.9 to 408.2 kg), heavyweight heifers (362.9 to 408.2 kg), and heavyweight steers (408.2 to 453.6 kg). Within each steer weight class, carcasses were separated according to a ratio of ribeye area cm^2 per 45.36 kg of hot carcass weight: heavy muscled ($\geq 9.10 \text{ cm}^2$) and light muscled ($< 9.10 \text{ cm}^2$). Carcasses were fabricated into boneless primals/subprimals and minor cuts, and external fat was trimmed to $\leq 0.64 \text{ cm}$. Subprimals, along with associated fat, lean trim, and bone, were weighed. Then-current market prices were used for value purposes. Data in this study

revealed yield and value differences among current YG 4 carcasses. As expected, carcasses from heifers had more trimmable fat than steers ($P<0.05$). Steers exhibited a higher red meat yield ($P<0.05$) and higher yields of certain cuts from the chuck ($P<0.05$) than heifers. Assigning values to carcass cutout components showed 22 of the 29 components differed between heifers and steers ($P<0.05$), and 23 of the 29 components differed in at least one of the gender and weight groups ($P<0.05$). Additionally, 13 of the 29 carcass components differed in value between lightweight and heavyweight heifer carcasses ($P<0.05$). Total carcass value differed between steers (\$574.43 to \$639.74) and heifers (\$507.05 to \$568.20) ($P<0.05$), between lightweight (\$574.43 to \$585.05) and heavyweight (\$627.84 to \$639.74) steers ($P<0.05$), and between lightweight (\$507.05) and heavyweight (\$568.20) heifers ($P<0.05$). However, no significant differences were observed in total value per 45.36 kg. With the exception of gender, there were no clear associations in carcass traits that could more accurately categorize value differences in USDA YG 4 carcasses. However, developing a prediction equation based on a carcass value endpoint may be beneficial in marketing carcasses of different gender and fatness categories.

Keywords: Beef, Carcass yield, Cutability

Nutrient content of USDA Prime, Choice, and Select top loin steaks cooked to different degrees of doneness

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One of the unique challenges of beef is that consumers have personal preferences for the degree of doneness of the steaks they prepare or have prepared for them. Currently, beef nutrition information fails to report caloric values based on multiple endpoint temperatures or doneness. Because degree of doneness is an important variable to the consumer's overall acceptance of beef steaks, such information should be more readily available. The objective of this study was to determine the role of USDA quality grade on the nutrient composition of beef steaks when cooked to different degrees of doneness. Ten steaks were obtained from each of 5 USDA Prime, 5 USDA Choice, and 5 USDA Select strip loins and assigned to one of 5 degree of doneness treatments (2 sets of treatments per strip loin): raw, medium rare (63°C), medium (71°C), well done (77°C), and very well done (82°C). Raw or cooked steaks were dissected into separable tissue components: lean, fat, and refuse. Proximate analyses (protein, moisture, fat, and ash) were conducted on the lean. With increasing degree of doneness, cooking yield and percent moisture decreased ($P<0.05$) resulting in differences such that a 250 g steak cooked to medium rare would yield 22 g more than a steak of equal weight cooked to very well done. Likewise, as degree of doneness increased, percent fat and protein also increased (both $P<0.05$) while the percent of separable lean decreased slightly, but only very well done steaks had ($P<0.05$) less separable lean. Grade did not ($P>0.05$) have any influence on cooking yield or the percentage of separable lean. USDA Select steaks had ($P<0.05$) less fat and more separable refuse when compared with USDA Choice and USDA Prime steaks. USDA quality grade influenced ($P<0.05$) the percentage of chemical fat, moisture, protein, and ash found in top loin steaks such that fat increased as grade increased while protein decreased. With increasing grade, caloric value increased: there was a 46.1% increase in caloric values between Select and Prime steaks. There was a 9.0% increase in caloric values between medium rare and very well done steaks: for every increase in a degree of doneness, there was ~18 kJ increase in a 100 g edible portion. Degree of doneness and USDA quality grade plays important roles in the ultimate caloric value in top

loin steaks. Differences in caloric values based on degree of doneness should be a component of the USDA National Nutrient Database for Standard Reference.

Keywords: Nutrient content, Proximate analysis, Degree of doneness

Pork carcass traits and meat yields as affected by ractopamine hydrochloride and immunocastration

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The objective of this study was to evaluate the effects of ractopamine (RAC) and immunocastration on pork carcass quantitative traits and to clarify possible interactions. Two hundred and 13 TOPIGS crossbred pigs (Tempo sires×Topigs 40 dams) from a commercial farm were grouped in females (FE), physically castrated (PC) and immunocastrated boars (IC), fed or not with ractopamine hydrochloride (7.5 mg/kg, Ractosuin, Ourofino Agrobusiness) for the final 21 d before slaughter. The boars designated to immunocastration received 2 doses of vaccine 8 and 4 weeks before slaughter, as recommended (Improvac, Pfizer Animal Health). Based on hot carcass weight and HPG (Hennessy Grading Probe) fat and muscle depth, were selected 10 pigs of each combination ractopamine dietary and sex, belonging to the average interval of ± 2 standard deviations. During slaughter, these variables (hot carcass weight and HPG fat and muscle depth) were collected. After chilling, carcass weight and length, and backfat thickness (first thoracic rib, last thoracic rib and last lumbar vertebrae, and its average) were recorded. Fat depth and longissimus muscle area (LMA) were measured between the 10th and 11th rib. Then, carcasses were divided into 11 primal cuts according to the EU reference method. The experiment was carried out as a factorial (2×3) arrangement with RAC diet (0 and 7.5 mg/kg) and sex categories (FE, PC and IC). Data were analyzed by ANOVA using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC) with a model including RAC, sex, and their interaction. Least squares means were separated by the PDIFF, and statistical differences were declared at $P<0.05$ level. RAC presented better results over the control, with increases ($P<0.05$) in Hennessy loin depth, ham and loin total weight and lean meat means. Considering gender means, the PC had higher ($P<0.05$) carcass weight, carcass length, and backfat thickness at the 3 locations and its average. Also had higher ($P<0.05$) ham, loin, to-ventral part of the belly, shoulder and hind shank total cut weight than FE and IC. But FE were leaner compared with PC and IC, and had higher ($P<0.05$) LMA. A few interactions RAC×Sex were detected ($P<0.05$) for the traits: HPG fat depth, backfat thickness at the last thoracic rib and average backfat, favoring RAC treated PC. It was concluded that ractopamine have favorable effects on ham and loin lean meat quantities. Carcasses from IC and FE pigs are leaner than carcasses from PC pigs. There can be some interaction with ractopamine treated, physically castrated pork carcass showing thicker backfat measurements.

Keywords: Ractopamine, Lean pork, Immunocastration

Effect of harvest endpoint on composition of primal cuts, shear force, sensory and texture attributes of male Boer and Kiko goats

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Goat meat is becoming increasingly popular in the United States, but its consumption is primarily in ethnic and rural markets. Increasing goat meat production and ensuring palatability of goat meat products may improve the industry. Thus, the objectives of this research were to examine carcass composition, tenderness, and sensory parameters of popular meat goat breeds at various stages of growth. Intact male Boer and Kiko goats were harvested after 0, 4, 8, or 12 wk on a high-protein concentrate diet (n = 6 goats per treatment combination). Composition of shoulder, foreshank, neck, breast, ribs, rack, loin, sirloin, leg, hindshank, trim and a 9–11 rib section were determined and compared with the composition of an entire carcass side. Warner–Bratzler shear force (WBSF) of the *Longissimus lumborum*, *Infraspinatus*, *Supraspinatus*, *Gluteus medius*, *Biceps femoris*, *Adductor*, *Psoas major*, *Semimembranosus*, and *Semitendinosus* muscles and texture profile analysis (TPA) of ground patties were evaluated. Soluble and insoluble collagen content of the *Longissimus thoracis* was determined. A trained sensory panel evaluated patties for aroma, taste, and texture attributes. Increased time on feed led to increased fat in the shoulder, breast, rack, loin, sirloin, leg, hindshank, ribs, neck, and trim ($P<0.05$). Boer carcasses also had a greater percentage of fat than Kiko carcasses in the shoulder, sirloin, leg, hindshank, ribs, and trim ($P<0.05$). Correlations between composition of the shoulder and the entire side were significant ($P<0.05$) for percent bone ($r=0.88$), percent fat ($r=0.84$), and percent muscle ($r=0.91$). Significant correlations also existed between composition of the 9–11 rib section and the entire side ($P<0.05$) for percent bone ($r=0.59$), percent fat ($r=0.85$), and percent muscle ($r=0.37$). Increasing feeding duration led to decreased WBSF of *Longissimus*, *Semitendinosus*, and *Infraspinatus* muscles ($P<0.05$), but collagen content and solubility were not changed ($P>0.05$), suggesting that cold shortening may have caused toughening of these muscles in smaller, leaner carcasses. Springiness, hardness, and cohesiveness TPA values were not affected by breed or feeding duration ($P>0.05$). Increased feeding duration increased aroma intensity and goaty, bloody, musty, and liver/organy aromas; salty, bitter, umami, grassy, goaty, fat, liver/organy, metallic, earthy, and chemical tastes; and juiciness and oiliness, while decreasing chewiness and crumbliness ($P<0.05$). Results indicate that younger, smaller goats produced leaner carcasses with less intense aroma and flavor attributes; however, certain muscles from smaller carcasses may be tougher. Also, the 9–11 rib section may be less useful for predicting carcass composition of goats than it is for other species.

Keywords: Goat, Sensory, Tenderness

Predicting beef tenderness using image texture features

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Beef tenderness is an important quality trait of meat for consumer satisfaction. The objective of this study was to investigate the usefulness of raw meat surface characteristics (texture) in predicting cooked beef tenderness. Texture features, including 88 gray level co-occurrence, 81 fast fourier transform (FFT), and 48 Gabor wavelet filter texture features were extracted from digital images of fresh beef obtained using a laboratory-based color camera (Model S2100HD, Fujifilm corporation, Japan) imaging system. Images were obtained on 2.54 cm thick cross-sectioned steaks cut from the longissimus thoracis (ribeye roll; n = 109; tender n = 86; tough n = 23), semimembranosus (inside round; n = 93; tender n = 48; tough n = 45), biceps femoris (outside round; n = 77; tender n = 67; tough n = 10), and supraspinatus (chuck tender; n = 81; tender n = 58; tough n = 23) muscles. Steak samples were segregated into tough and tender classification groups based on Warner–Bratzler shear force (WBSF) values whereby a WBSF

of 4.0 kg or less was considered tender. The 217 texture features were submitted to STEPWISE multiple regression and support vector machine (SVM) analysis to establish prediction models for tender or tough beef. A subsample (80%) of tender or tough classified steaks were used to train the SVM or establish the multiple regression model which was then validated on the remaining (20%) “test” steaks. Twenty out of 100 (20%) steaks scanned were classified as tough. Both stepwise and SVM models correctly classified tender biceps femoris steaks (100%). For longissimus thoracis samples, the SVM machine method correctly predicted 100% of the tender steaks while the STEPWISE model accounted for 80% of the tender ribeye steaks. Tender semimembranosus steaks were correctly identified with an accuracy of 60% using the SVM model and STEPWISE accounted for 50% of tender steaks. When all steak samples were pooled (no separate distinction of a specific cut) and analyzed by the SVM and STEPWISE model, the results were similar with the SVM model correctly identifying tender steaks 100% accurately and the STEPWISE equation identified 94.9% of the steaks correctly as tender. Finally, the SVM model was 100% correct characterizing tender supraspinatus steaks, while the STEPWISE model 70% accurate. The SVM and STEPWISE models were considerably less accurate in classification of designated tough samples. The texture features isolated in the present study through development of SVM and STEPWISE models show potential as a means to identify tender steaks, regardless of the anatomical origin.

Keywords: Beef, Tenderness, Texture

Effects of temperament classification and breed type on carcass characteristics, tenderness and carcass value in feedlot heifers

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The objectives were to determine the effects of temperament classification and breed type on carcass characteristics, tenderness and carcass value in Angus (AN; n=184), Brangus (BN; n=266), Simbrah (SI; n=196), and Braford (BO; n=241) heifers obtained over 3 years from Deseret Ranch. Each year, heifers were received in 2 groups; fall and spring (initial age and body weight of heifers = 337 vs. 501 ± 86 d and 278 vs. 324 ± 48 kg, respectively). Heifers were fed a high-grain diet (ME = 3.08 Mcal/kg DM), and feed intakes were measured using a GrowSafe system for 70 d. Heifers were fed in group pens and harvested at an average backfat thickness of 1.2 cm in 2 groups. Exit velocity (EV), the rate heifers exited a squeeze chute, was used as an objective measure of temperament. Within trial, heifers were classified into calm, moderate, and excitable temperament groups based on ±0.5 SD from the mean EV. Heifers were commercially harvested and USDA Yield (YG) and Quality grade (QG) characteristics obtained. Warner-Bratzler (WBSF) and Slice shear force (SSF) values were measured on top loin steaks after 1, 7 and 14 d of vacuum-packaged storage at 2 °C. Carcass value was based on premiums for QG (Prime = +0.24), and discounts for carcass weight (<250 kg = -0.37; >454 kg = -0.44), QG (Select = -0.18; Standard = -0.44), YG (>5 = -0.40; >4 and <5 = -0.24) and tenderness (WBSF >3.9 kg = -0.44). Data were analyzed using a model including fixed effects of temperament, breed, season (fall or spring), interaction terms and random effects of year and pen. Calm-temperament heifers had heavier ($P<0.05$) carcasses (296 vs 287 kg), higher KPH% (2.36 vs 2.18), and greater marbling scores (463 vs 435), but similar ($P>0.05$) fat thickness and REA compared with excitable heifers, respectively. Calm heifers had greater ($P<0.01$) YG (2.98 vs 2.18), lower ($P<0.01$) WBSF on d 1, 7, and 14 (3.41 vs 3.88; 2.51 vs 2.90; and 2.38 vs 2.58 kg, respectively), lower ($P<0.013$) SSF values

on d 1, 7, and 14 (18.80 vs 20.83; 13.21 vs 14.52; and 11.46 vs 12.76 kg, respectively), and greater ($P<0.001$) carcass values (982 vs 937 \$/carcass) than excitable heifers, respectively. BO heifers had lighter carcass weights, smaller REA, and higher ($P<0.001$) YG than SI heifers, with AN and BN heifers being intermediate. Marbling scores were lower ($P<0.001$) and d 1 WBSF was greater ($P<0.001$) for BO and SI heifers compared with AN and BN heifers. There were interactions between breed and season for carcass weight ($P=0.03$), YG ($P=0.02$), d 1 SSF ($P=0.01$), and carcass value ($P=0.03$). In this study, heifers with calm temperaments produced carcasses with heavier weights, higher marbling scores, lower WBSF and SSF values, and a \$45/hd greater grid-formula value than heifers with excitable temperaments. Results suggest that temperament classification upon feedyard arrival using EV can be used to sort calves into outcome groups that differ in weight, marbling and carcass value. Sorting heifers into outcome groups would reduce variation within a group in carcass characteristics and tenderness and allow marketing of value-based marketing to maximize these characteristics.

Keywords: Temperament, Breed, Tenderness

Estimation of relationships between carcass traits of young beef with Warner-Bratzler shear force of longissimus steaks

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The objective of this study was to determine the relationship between carcass traits of young beef with Warner-Bratzler shear force (WBSF) of longissimus steaks aged for 7, 14, or 21 d postmortem. Data from a total of 13,167 steaks were obtained with known carcass characteristics and WBSF value. Pearson correlations were generated, and stepwise linear regression analyses were conducted to determine the influence of carcass yield and quality traits on WBSF. Steaks represented traditional pre-harvest management strategies for market cattle, and various biological types were represented. When all postmortem aging periods were combined (7, 14, and 21 d), marbling score had the strongest relationship ($r = -0.23$; $P<0.01$) to WBSF. Yield grade had a similar relationship to WBSF ($r = -0.18$; $P<0.01$), which was greater than all of the individual factors accounted for by yield grade. All yield grade factors were related to WBSF ($P<0.01$); however, coefficients ranged from -0.11 to 0.12, indicating weak linear relationships. Marbling alone accounted for 5% of the variation in shear force. The addition of hot carcass weight (HCW), ribeye area (REA), and kidney, pelvic, and fat percentage (KPH) increased the coefficient of determination of the final regression equation to 0.07. For steaks aged 7 d postmortem, marbling had the strongest relationship to WBSF ($r = -0.27$; $P<0.01$), followed by yield grade ($r = -0.27$), REA ($r = 0.15$), 12th rib fat thickness ($r = -0.11$), and KPH ($r = 0.10$). Hot carcass weight was not correlated to shear force of steaks aged 7 d ($P>0.05$). When steaks were aged 14 d postmortem, marbling score had the strongest correlation ($r = -0.20$; $P<0.01$) to WBSF. Yield grade had a similar relationship to WBSF ($r = -0.18$; $P<0.01$), which was greater than all of the individual factors accounted for by yield grade. Of the yield grade factors, 12th rib fat thickness had the strongest relationship to WBSF ($r = -0.11$), followed by REA ($r = 0.09$), HCW ($r = -0.05$), and KPH ($r = -0.05$). Marbling again had the strongest relationship ($r =$

–0.27; $P < 0.01$) to WBSF for steaks aged 21 d postmortem, followed by yield grade ($r = -0.17$), REA ($r = 0.12$), 12th rib fat thickness ($r = -0.11$), KPH ($r = 0.06$), and HCW ($r = -0.04$). Regression analysis revealed that marbling, REA, HCW, and KPH could account for 10, 6, and 9% of the variation in WBSF of steaks aged 7, 14, or 21 d, respectively.

Keywords: Beef, Carcass traits, Shear force

Tenderness genotype and growth enhancement technology effects on performance, carcass characteristics and tenderness in feedlot heifers

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Objectives were to determine if growth-enhancement technologies (GET) affect carcass and tenderness characteristics in feedlot heifers of divergent tenderness genotypes (TG). King Ranch Santa Cruz heifers ($n = 350$) were genotyped for tenderness using molecular breeding values (Pfizer Animal Genetics), and the most ($n = 64$; TN) and least ($n = 64$; TO) tender genotypes heifers were selected. Heifers were blocked by BW and randomly assigned to implant (Revalor IH followed by Revalor H at 70 d re-implant, Intervet Inc.; RV) or no implant (no-RV) treatments. Within pen ($n = 4$), half of the TO and TN heifers received the RV treatment. During the last 28 d, pens were randomly assigned to receive the β -adrenergic agonist (Optaflexx™, Elanco Animal Health; BA) or no β -adrenergic agonist (no-BA) treatments. Heifers were harvested at 1.2 cm of 12th rib fat thickness, and USDA Quality grade (QG), pH, L*, a* and b* color space values, lean color, and Yield grade (YG) attributes determined. Warner-Bratzler (WBS) and Slice shear (SS) force values were measured on the top loin LM of 2.54 cm steaks after 1, 7, 14 d of vacuum-packaged storage at 2 °C. Sarcomere length (24 h) and 14 d desmin degradation. LM lipid and moisture (%), and collagen content were determined. Data were analyzed with Proc GLIMMIX using fixed effects of TG, RV, BA, and their interactions, and random effect of BW group. Initial and final BW were not affected by TG, RV, or BA treatments ($P = 0.05$). RV treatment increased ADG, but ADG was not affected by TG or BA. TG did not affect carcass and tenderness characteristics, but lean from TN heifers had lower ($P = 0.001$) desmin levels. Carcasses from RV heifers had less KPH, lower YG and QG, higher desmin levels, less LM lipid, and lower soluble collagen than carcasses from no-RV heifers. Steaks from RV heifers had higher 1 and 7 d WBS and SS values. Carcasses from BA heifers did not differ ($P > 0.05$) in carcass characteristics, sarcomere length, pH, color space values and desmin. Steaks from BA heifers were darker ($P = 0.004$) and lower LM lipid ($P = 0.001$) than steaks from no-BA heifers. Soluble and total collagen was lower ($P < 0.05$) in steaks from BA heifers. Day 1 WBS was higher ($P = 0.007$) in steaks from BA heifers. BA affected marbling score ($P = 0.03$) and LM lipid ($P = 0.02$) of TO heifers, but not TG heifers. Steaks from TO BA heifers were lower in LM lipid than steaks from TO no-BA heifers (382.4 vs 430.1 and 3.18% vs 4.75%, respectively); whereas BA did not affect LM lipid of lean from TN heifers. RV \times TG affected ($P = 0.04$) 7 d WBS. Steaks from TN no-RV heifers were more tender than steaks from TN RV, TO no-RV, and TO RV steaks (2.64 vs 3.66, 3.54 and 3.61, respectively). Steaks from no-BA, no-RV heifers had higher ($P = 0.03$) collagen solubility than steaks from no-BA RV, BA no-RV, and BA RV heifers (13.58 vs 8.95, 8.94, 9.01, respectively). Results suggest that TG interacts with GET to impact carcass quality traits.

Keywords: Tenderness, Genetic markers, Growth enhancement

Understanding the grade B4 beef in Alberta

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Canadian grade B4 beef carcasses are penalized by \$0.35 per pound because the *longissimus lumborum* is dark, firm, and dry (DFD). The number of DFD carcasses in Alberta has nearly doubled since 2004 and spiked in 2007 to 2.5% in Alberta and 4.6% in Saskatchewan/Manitoba/British Columbia. DFD carcasses were more common in Eastern Canada, but have recently declined to record low levels. Classical DFD beef is caused by a combination of stress and insufficient muscle glycogen before slaughter, which results in an abnormally high post mortem muscle pH of 6.0 and dark lean color. This project surveyed the pH of muscles of 179 DFD carcasses over 5 visits to an Albertan abattoir and identified sub-classes within the Canadian B4 grade based on muscle pH ($\text{pH} > 6.0$, $5.8 < \text{pH} < 6.0$, $\text{pH} < 5.8$). The sub-classes of grade B4 beef are as follows and the corresponding occurrence rates: classic B4; 74% occurrence rate, borderline B4; 20% occurrence rate, and atypical B4; 6% occurrence rate. Carcasses that grade Canadian B4 were lighter than Canadian AA carcasses ($P = 0.0047$). Canadian AA carcasses and Atypical B4 carcasses showed no differences in pH values at muscle dissection, however differences in color were observed in the following muscles: *longissimus lumborum*, *longissimus thoracis*, *biceps femoris*, *semitendinosus*, *semi-membranosus*, and adductor according to Japanese Meat Grading Association acrylic color standards. Differences in shear force values have shown that borderline B4 beef is tougher than other sub-classes of grade B4 beef ($P = 0.001$). Differences in the glucidic metabolites of the *longissimus lumborum* were found between classical B4 beef and AA beef when lactate, glycogen, and free glucose ($\mu\text{mole.g}^{-1}$) were measured ($P < 0.001$, $P = 0.0146$, $P < 0.001$, respectively). However no differences were found in glucidic metabolites between the Atypical and AA beef in all measurements except free glucose suggesting that Atypical B4 carcasses have sufficient glycogen reserves ante mortem to attain a bright red color and a normal pH of 5.6. The DFD muscles within Atypical B4 carcasses may not be caused by the same mechanisms as the classical B4 theory states. Future research will examine the biochemical differences among DFD beef to better understand the mechanism producing dark lean.

Keywords: DFD (dark, firm, and dry), Dark cutting beef, Canadian grade B4

Predicting fluid loss in beef steaks injected with salt and phosphate with or without a dehydrated beef protein water binding ingredient

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Injection of whole muscle beef cuts with a solution containing water, salt (NaCl) and sodium phosphates (SP) is economically important to processors because it offsets the loss of fluid during storage (purge), as well as enhancing flavor, juiciness and tenderness. Salt and SP are major contributors of sodium (39.3 and 31.2%, respectively). Recently, there has been an increased focus from the media and public on sodium in foods. Efforts to reduce sodium in injected meat products are needed. The objective of this study was to use response surface modeling to determine prediction equations and construct surface maps for the loss of fluid from injected beef steaks during storage as affected by the level of salt and SP. In addition, a

similar evaluation was made in the presence of a beef-based water binding ingredient, dehydrated beef protein (DBP). Paired US select beef strip loins were quartered before being injected to 110% of initial weight with a brine containing salt and SP (CON) or salt, SP and 5% DBP. A central composite design was used to select 9 combinations of 5 salt levels (0, 0.53, 1.8, 3.07 and 3.6%) and 5 SP levels (0, 0.66, 2.25, 3.84 and 4.5%). Steaks were sliced and overwrapped before being placed in dark storage for 4 d. Several purge determinations were calculated. $Purge_{5d}$ is the purge loss from slicing through d 5 as a percentage of the steak weight. $Purge_{total}$ is the fluid lost through d 5, including that lost by the loin between injection and slicing, as a percentage of the steak weight. Brine $loss_{total}$ is the fluid lost through d 5, including that lost by the loin between injection and slicing, as a percentage of the total fluid injected into the loin. Least squares estimators and subsequent 3-dimensional surfaces and contour plots were generated using SAS. $Purge_{5d}$ values ranged from 0.6% to 4.6% for CON and 0.3% to 2.1% for DBP. The lowest predicted $Purge_{5d}$ values occur near the maximum combination of salt and SP for CON brines or moderate values of SP or moderate combinations of salt and SP for DBP brines. $Purge_{total}$ values are predicted to be lowest at maximum combined values of salt and SP for CON brines or moderate combined values of salt and SP for DBP brines. Observed $Purge_{total}$ values were as high as 6.8% for CON brines, but only 2.8% for DBP brines. Brine $loss_{total}$ values are predicted to be as high as 80% at minimum levels of salt and SP in CON brines. The presence of DBP reduces that value to just over 40%. With DBP, minimum Brine $loss_{total}$ values (<10%) can be attained with moderate levels of SP or maximum levels of salt. The equations generated here and the DBP product could help producers to achieve acceptable purge while reducing sodium use.

Keywords: Injection, Sodium, Phosphate

Reducing sodium levels in frankfurters by using naturally brewed soy sauce and natural flavor enhancer

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Sodium chloride serves many important functions in processed meats, contributing to desirable quality and food safety characteristics; however, renewed interest exists in reducing sodium in the human diet. Due to salt's functions in processed meats, it is not feasible to completely remove it from formulations. Current salt usage levels are already near minimum thresholds for important quality aspects of processed meats, and further reductions could be detrimental. This study investigated consumer sensory and quality impacts associated with partial replacement of normally added NaCl using naturally brewed soy sauce (SS) or natural flavor enhancer (NFE; a modified soy sauce). Varying levels of either SS or NFE (SS/NFE) were used with NaCl and/or KCl to comprise treatments (TRT) in 3 separate research phases, which investigated formulation NaCl replacement (Phase I) and NaCl (Phase II)/Na (Phase III) reduction. All phases included a 100% NaCl control (C). Phase I included 25%, 50%, 75%, and 100% NaCl replacement by SS/NFE. Phase II investigated a 50% SS/NFE + 50% NaCl base formulation (TRT 1) as well as 10% (TRT 2), 20% (TRT 3), and 30% (TRT 4) NaCl reductions. To allow further sodium reduction, phase III incorporated SS/NFE, NaCl and KCl to investigate if flavor enhancing effects of SS/NFE could attenuate bitterness associated with KCl. Phase III included the following TRTs: 50% SS/NFE + 50% NaCl base formulation (TRT 1) along with 20% (TRT 2), 35% (TRT 3), and 50% (TRT 4) NaCl reductions. Phase I results identified a 50% replacement of NaCl with SS/NFE as the baseline for subsequent phases. Phase I consumer sensory responses indicated

that SS/NFE containing TRTs were perceived as saltier ($P<0.05$) than C. While SS TRTs in phase II were not different from each other for overall liking, TRTs 2 and 3 had higher ($P<0.05$) overall liking scores than C. When using NFE, TRTs 2, 3, and 4 possessed higher ($P<0.05$) overall liking ratings than C. Furthermore, SS/NFE TRT 1 was rated saltier ($P<0.05$) than TRTs 2, 3, 4 and C, suggesting that SS/NFE could enhance the perception of saltiness. Phase III sensory responses revealed higher ($P<0.05$) overall liking scores for SS TRTs 1 and 2 compared with C. NFE TRTs 1, 2, 3, and C were not found to be different but were all rated higher ($P<0.05$) for overall liking than TRT 4. SS/NFE TRT 1 was rated higher ($P<0.05$) for saltiness than SS/NFE TRTs 2, 3, 4, and C. However, SS TRTs 3 and 4, as well as NFE TRTs 1 and 4, were rated slightly, but significantly, higher ($P<0.05$) for bitterness than C suggesting a bitter note may have been detectable. All phase II and III SS/NFE TRTs possessed lower ($P<0.05$) textural hardness values than C, and minimal differences were found for emulsion stability, color, and pH. This research has demonstrated that SS and NFE can be utilized to reduce the sodium chloride/sodium level of frankfurters without negatively impacting quality and sensory characteristics. SS and NFE have also been shown to possess a salt enhancing effect, thereby offering the ability to reduce added salt while still maintaining salty flavor in reduced sodium frankfurters. This research also suggested that a synergistic relationship may exist between SS/NFE, KCl and NaCl, allowing for even greater KCl utilization potential.

Keywords: Frankfurters, Sodium reduction, Soy sauce

Tomato puree as an antioxidant in raw pork emulsion

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Discoloration and lipid oxidation are major factors in the deterioration of shelf life of muscle foods such as pork and can be controlled by synthetic antioxidants. Use of natural antioxidants, especially lycopene, has received considerable attention. Processed tomato products are excellent sources of lycopene (red carotenoid), which is more bioavailable in the processed products such as tomato puree (TP) than in raw tomatoes. The efficacy of TP as an antioxidant was evaluated at different levels (0%, 5.0% T1, 7.5% T2 and 10.0% T3) in the raw pork emulsion incorporated with 10% fat and 2% salt. Various physico-chemical quality parameters (pH, titrable acidity; TA, metmyoglobin content, TBARS, free fatty acid; FFA, and peroxide value; PV), concentration of active components (lycopene and β -carotene content) and instrumental color were evaluated for 9 d under aerobic refrigerated storage. The pH of pork emulsion decreased ($P<0.05$) with the increase in level of TP and storage, however pH increased on d 7 and 9 of storage. The TA increased ($P<0.05$) with the decrease in pH. Lycopene and β -carotene content increased ($P<0.05$) from T1 to T3 and decreased throughout the storage in all TP-treated products. Percentage metmyoglobin formation was higher ($P<0.05$) in the control than TP-treated products and was recorded lowest for T3. Metmyoglobin content increased linearly during storage in control and TP-treated groups. The addition of TP increased a^* (redness) and b^* (yellowness) values but decreased the L^* (lightness) value compared with the control. TBARS, FFA, and PV values decreased with the increase in level of TP and concentration of active components. Lipid oxidation increased during storage and was lowest for T3. Furthermore, it was lower ($P<0.05$) in TP-treated group than in the control throughout storage. The odor scores were comparable among TP-treatments and the control during initial storage days then decreased on further storage. However, odor scores were better maintained in TP-treated group than in the control.

Results suggested that TP can effectively improve oxidative stability, color, and odor of raw pork emulsion during refrigerated storage.

Keywords: Tomato puree, Lycopene, Raw pork emulsion

Effects of liquid and wood smoking combined with potassium lactate and acetate on the quality and inhibition of *Listeria monocytogenes* growth in ready-to-eat smoked catfish fillets

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The objective of this study was to evaluate the effects of liquid and wood smoking with a potassium lactate (PL) and acetate (PA) combination on the quality and inhibition of *L. monocytogenes* growth in RTE smoked catfish fillets. A split-plot in a randomized complete block design was utilized to determine chemical, sensory and microbial changes in smoked catfish fillets. Catfish fillets tumbled with and without PL and PA were assigned as the main plots. No smoke (NS), wood smoke (WS), liquid smoke 1 (LS1) and liquid smoke 2 (LS2) were assigned as the subplots. No differences ($P > 0.05$) existed among treatments with regards to pH, Aw, moisture content, total salt content, water-phase salt, and tenderness, but WS and LS1 led to the production of catfish with higher ($P < 0.05$) CIE a^* values and lower ($P < 0.05$) CIE L^* values. WS treated catfish had higher ($P < 0.05$) CIE b^* values than catfish from LS1 while CIE b^* values of NS and LS2 were similar ($P > 0.05$). Wood smoke with antimicrobials (WSWA) showed greater inhibition of *L. monocytogenes* than other treatments with the exception of LS1 with antimicrobials. Consumers preferred smoked catfish fillets treated with WS to LS1 with respect to appearance, odor, flavor, texture and overall acceptability. In conclusion, use of PL and PA did not impact the quality and sensory properties of smoked catfish fillets but had a synergistic effect with wood smoke constituents in inhibiting the growth of *L. monocytogenes*.

Keywords: Catfish fillet, Wood smoke, Potassium lactate and acetate

Turkish pastirma, a dry cured beef product and new trends in pastirma processing

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Pastirma, a popular dry cured beef product made from whole muscle, is an intermediate moisture food. To produce pastirma, the exterior fat and connective tissue are removed from the meat, and then curing, drying, pressing and coating the resultant meat with çemen paste processes are applied. Although pastirma is defined as cured and dried meat product, partial fermentation also occurs due to natural microbial flora of meat. Pastirma is generally made from certain beef cuts; however, there is a growing trend to use alternative meats such as turkey, chicken and fish meat in its processing. The inclusion of tumbling and brine injection are other new approaches and tumbling significantly decreased microbial count and improved the sensory properties of dry-cured pastirma. Application of heat process in pastirma manufacture was also investigated and was reported to positively affect sensory properties of pastirma. Use of starter cultures decreased nitrite and

nitrate residues in pastirma improved chemical quality parameters such as pH, residual nitrite and nitrate and instrumental color. Manufacturing restructured pastirma is another hot topic and is currently under research. Pastirma, a traditional meat product, does not have enough recognition and market share among traditional meat products. Its relatively high price, longer production time and non-standardized production procedures are ongoing issues. Standardizing production steps especially pressing stage, using controlled-artificial drying methods and optimizing raw meat quality need to be addressed. Moreover, a better production control system to satisfy consumer demands and to avoid potential food safety hazards is highly needed. In addition, alternative ingredient technologies (use of starter cultures) and processing steps (i.e., tumbling) may be implemented to improve pastirma quality further.

Keywords: Pastirma, Meat processing, New technologies

Reduction in oil uptake by using defatted rice bran in popcorn chicken and corn dogs

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Until recently, rice bran, a by-product of rice milling, was considered unfit for human consumption or prolonged storage. Due to new stabilizing technology to inactivate the lipase, rice bran is no longer viewed as waste material. In June 2008, stabilized rice bran was approved by the USDA as a binder in comminuted meat and poultry products such as sausages, nugget-shaped chicken patties, meatballs, meatloaf and meat patties. Further processing of rice bran by removal of the oil fraction results in a product termed defatted rice bran (DRB). DRB provides an allergen-free, functional ingredient which can replace a portion of the wheat flour in batter/breading systems used in fried products. The low level of gluten in DRB may have a reduced affinity for oil and therefore, could potentially reduce oil uptake during the frying process. The objective of this study was to determine the reduction in oil uptake when DRB was used to partially replace pre-dust, batter and breading in popcorn chicken and batter mix in corn dogs. Chicken breast was tumbled and marinated with salt, water and phosphate solution to 20% of its green weight. The marinated chicken was diced into 8 g pieces and coated with pre-dust, hydrated batter and breading mix each containing 0%, 5%, 10%, 15% and 20% DRB. Total pickup was targeted at approximately 30% of the raw marinated chicken weight. The coated chicken pieces were par fried for 30 s. in oil at 185 °C, frozen overnight, then fully fried to an internal temperature of 73.9 °C. Results show that the fat content of the popcorn chicken after fully frying was significantly ($P < 0.05$) reduced by 10.9%, 13.1%, 21.7% and 22.1% and finished product calories were significantly ($P < 0.05$) reduced by 2.4%, 4.9%, 7.3% and 9.8% respectively when DRB was used at 5%, 10%, 15% and 20% in the pre-dust, batter and breading compared with the control. Regular fat beef hot dogs were coated with corn dog batter each containing 0% 10% and 20% DRB. Total hydrated batter pickup was targeted at approximately 50% of the hot dog weight. The corn dogs were par fried for 30 s in 185 °C oil, frozen overnight and fully fried in 176.7 °C oil for 8 min. Results show that the fat content of the corn dogs after fully frying was significantly ($P < 0.05$) reduced by 30.9% and 61.8% and finished product calories were significantly ($P < 0.05$) reduced by 8.6% and 25.7% respectively when DRB was used at 10% and 20% in the corn dog batter compared with the control. DRB is an economical, functional ingredient that can significantly reduce the oil uptake and caloric content of fried breaded meat and food products. Additional benefits of using DRB include improved crispiness over extended holding times post frying, improved color and fiber contribution. The value of

using DRB in fried breaded products is the reduction in caloric intake for the consumer, while the manufacturer and purveyor take advantage of an economical process to make healthier products. DRB has widespread potential in the modification of the current and development of next-generation products.

Keywords: Defatted rice bran, Reduction in oil uptake, Fried products

Impact of rosemary and green tea extract on the oxidative and flavor stability of cooked ground chicken patties

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The impact of 0.2% rosemary extract (RE) or 0.2% of a blend of rosemary and green tea extracts (RGT) on the sensory acceptance and lipid stability of cooked chicken patties were compared with an untreated control during 14 d of refrigerated (2 °C) storage. The chicken patties were prepared using a 1:1 mixture of skinless breast meat and thigh meat with skin. Sodium chloride (0.5%) was added to the meat before grinding. Flavor stability was evaluated by an informal sensory panel, and oxidative stability was measured by thiobarbituric acid reactive substances (TBARS), hexanal, and 2,4-decadienal. Two replicates of each treatment (n = 2) were prepared. Both the RE and RGT patties had lower ($P < 0.05$) TBARS than the control patties on all testing intervals. The RGT patties had lower TBARS ($P < 0.05$) than the RE patties on d 4, 6, 11, and 14. The natural extracts reduced ($P < 0.05$) the secondary oxidative byproducts, hexanal and 2,4-decadienal, beginning on d 6 and 4, respectively. The TBARS were correlated ($P < 0.001$) with both hexanal ($r = 0.9233$) and 2,4-decadienal ($r = 0.8764$), for all treatments and test periods. The sensory acceptance scores were consistent with the TBARS and the oxidative byproducts. The RGT patties had the highest acceptance scores at each sampling period, and the RE patties had higher scores than the untreated patties at all times except d 4. The results indicated that the use of RE or RGT had a positive impact on the flavor and oxidative stability of refrigerated, cooked chicken patties. Furthermore, the blend of rosemary and green tea extracts was more effective than the rosemary extract alone.

Keywords: Green tea, Rosemary, Chicken

Effect of tumbling or soak marination on whole muscle beef jerky compositional and sensory attributes

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Whole muscle beef jerky is commonly produced by using the traditional method of soaking beef slices in a marinade at least overnight, or by short time tumbling in a marinade. To compare the effect of marination technique on beef jerky compositional and sensory attributes, whole-muscle beef jerky was prepared in 3 repetitive batches from beef inside rounds following the Kansas State University Meat Laboratory formulation and processing steps. Two marination techniques, either 24-h soaking in a tub, or 20 min vacuum tumbling were used. Additionally, a liquid smoke-based anti-mold spray provided by Kerry Ingredients (Monterey, TN) was applied to half of each treatment after drying to evaluate detection of smoke flavor resulting in 4 treatments: 1) soaked/not sprayed (S); 2) soaked/sprayed (SS); 3) tumbled/not sprayed (T); and 4) tumbled/sprayed (TS). During production, 42.7% marinade by meat weight was used for soaking, with the final pickup percentage after soaking being used as the amount of marinade added to the tumbled treatment, with the goal of achieving

equal pickup levels between techniques. The amount of marinade picked up during soaking was 20.8–24.3% based on raw meat weight. There was an approximately 3% higher marinade pickup for soaked jerky vs. tumbled, so a full 100% uptake was not achieved during vacuum tumbling. Jerky moisture-to-protein ratio was 0.31 and was similar ($P > 0.05$) regardless of marination technique. Water activity (a_w) was similar ($P > 0.05$) for SS, T, and T with a mean a_w of 0.60, but slightly lower ($P < 0.05$) in S at 0.54. Salt concentration ranged from 4.66 to 7.27%. Soaked jerky contained 2.1% more ($P < 0.05$) salt than tumbled jerky, possibly due to the higher percent marinade pickup. A trained sensory panel found soaked jerky to have a slightly more salty and intense flavor ($P < 0.05$) than tumbled jerky, while the initial bite, chewiness, moisture, and off-flavor intensity was similar ($P > 0.05$) for soaked and tumbled jerky. Panelists found no difference in smoke flavor ($P > 0.05$) for jerky sprayed with a smoke derived anti-mold spray suggesting this product could be applied without changing flavor attributes. Using vacuum tumbling as a form of marination saves time compared with soaking beef slices for 24 h and produces jerky with many similar sensory attributes. However, if an equal level of marinade pickup is expected compared with soaking then additional marinade, a longer tumble time and/or a decreased tumbler volume needs to be considered as this may affect finished salt concentration and sensory flavor intensity.

Keywords: Beef jerky, Marination, Sensory

Evaluation of antioxidant and antimicrobial activities *Caesalpinia sappan L.* extract and its application on meat patties

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This study was carried out to investigate the antioxidant activities and antimicrobial activities of hot water extracts from 20 species of medicinal plants and evaluate meat products qualities added plant extract shown comparatively higher activities in antioxidant and antimicrobial properties. The following plant extracts have been tested: *Erigeron canadensis*, *Rehmannia glutinosa* Liboschitz var. *purpurea* Makino, *Solanum nigrum*, *Crataegus pinnatifida* Bunge var. *typica* Schneider, *Cnidium officinale*, *Pulsatilla koreana*, *Lycium chinense* Miller, *Akebia quinata* Decaisne, *Codonopsis pilosula* Nannfeldt, *Lonicera japonica*, *Bambusoideae*, *Hoelen cum Pini Radix*, *Caesalpinia sappan L.*, *Gleditsia sinensis* Lamarck, *Hovenia dulcis* Thunb., *Lonicera japonica* Thunberg, *Ledebouriellesesoides*, *Bupleurumfalcatum L.*, Seed of *Nelumbo nucifera* Gaertner and *Dioscorea batatas*. The antioxidant activities of medicinal plant extracts were evaluated by various antioxidant assays, including free radical-, hydroxyl radical- and superoxide anion radical- scavenging activities in the same concentration. Those various antioxidant activities were compared with standard antioxidants, butylated hydroxytoluene (BHT) and ascorbic acid (Vit. C). The highest activities of free radical (20.15% and 73.28%)-, hydroxyl radical (16.80% and 30.39%)- and superoxide anion radical (31.30% and 44.45%)-scavenging activities were obtained from the extract of *Caesalpinia sappan L.* (CA) ($P < 0.05$) in the concentration of 10 and 100 $\mu\text{g/mL}$, respectively. The antimicrobial effects of all these extracts were evaluated against *Escherichia coli* O157:H7, *Salmonella typhimurium*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Bacillus cereus* and *Pseudomonas aeruginosa*, *Candida albicans* and *Vibrio parahaemolyticus*. The agar disc diffusion methods were used to determine the zone of inhibition between the edge of the

filter paper and the edge of the inhibition area. The antioxidant and antimicrobial properties of water extract from *Caesalpinia sappan* L. (CA) were higher than the other tested medicinal plant extracts. Especially, the inhibition zones of CA extract were higher antimicrobial activities against *Bacillus cereus*, *Salmonella typhimurium* and *Candida albicans*, than the other extracts. CA extract was higher antioxidant activities in antioxidant and antimicrobial activities than the other extracts. Therefore, to boost antimicrobial and antioxidant characteristics in meat patties, CA extract was used (0, 0.1 and 0.2%) as additives in meat processing product. Meat patties with CA had a lower ($P<0.05$) TBARS, VBN, Total aerobic bacteria (TAB) values and higher ($P<0.05$) pH values than control samples during storage. However, no significant differences were found in sensory evaluation (color, aroma, off-flavor, taste and texture).

Keywords: *Caesalpinia sappan* L, Antioxidant, Antimicrobial

Revisiting fat stabilization in comminuted meat products

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Finely comminuted meat products, like frankfurters and luncheon meats, typically contain 20–30% fat. Classic emulsion theory was initially proposed to explain fat holding ability during cooking (FHA), where solubilized myofibrillar proteins (MFP) stabilize the fat/water interface to form an interfacial protein film (IPF) that prevents fat coalescence and flow. Recently more emphasis has been placed on 'entrapment' of fat within the protein gel matrix formed upon cooking. Even with this understanding, however, a major role of the IPF in fat stabilization is generally accepted. We instead postulate that FHA is directly linked to water-holding ability during cooking (WHA). The latter is mediated primarily by capillary pressure, a function of the gel matrix structure/composition (pore size, surface properties, and dissolved solutes) according to the Jurin rule. An IPF undoubtedly exists at the fat:matrix interface, but we believe at most it plays a minor role in determining FHA. Others have shown close correlation of WHA with FHA in cooking of sausages, and the present work further investigates this correlation. The content of MFP (all from lean chicken breast) of a standard frankfurter batter (minus added fat) was adjusted successively downward by addition of 0, 15% or 30% whey protein isolate (WPI) in substitution of MF protein, holding moisture content constant. Thus 'meat blocks' of 3 different 'bind quality' levels would be simulated; WPI (low calcium) serves as a substitute for sarcoplasmic meat proteins and is essentially non-gelling below 70 °C. Pork fat (20% w/w) was added to 2 additional sets of these 3 batters, as either a pre-emulsion (PE) prepared with a portion of the salted chicken meat, or directly (non-pre-emulsion; NPE). Our assumption was that an IPF formed around PE fat droplets would be excellent and constant when added into gel matrices that likely would vary considerably in WHA. WHA (and FHA, for fat-containing batters) were measured during cooking (as cook losses), plus water holding capacity (WHC) and fracture stress/strain of cooked, cooled gels were measured by micro-centrifuge and torsion, respectively. Gel morphology and pore size were examined by confocal laser scanning microscopy (CLSM) and scanning electron microscopy (SEM). As expected, WHA, WHC and gel fracture stress decreased with increasing substitution of WPI for MF protein in non-fat gels ($P<0.05$). The same trend was noted for fat-containing gels, whether fat was added PE or NPE. As WHA decreased, FHA during cooking also decreased accordingly such that the 2 were highly correlated ($P<0.001$). Marked changes in gel morphology, from fine- to coarse-stranded wherein ave. pore diameter increased $>3\times$, were noted as substitution of MF by WPI was increased up to 30%. Because PE of fat

imparted no additional stability to fat-containing gels as compared with NPE, the results can be interpreted as supporting our hypothesis that FHA corresponds directly to WHA during cooking, and that a fine-stranded, small pore-size matrix which exhibits high WHA and WHC likely also will exhibit high FHA. A strong/dense IPF likely is of little consequence when the average gel pore size favors poor WHA. Ongoing work will elaborate the properties of the IPF formed in each of the treatments described.

Keywords: Fat/water holding, Fracture, Microstructure

Development of a functional multivitamin microcapsule for utilization in a ready-to-eat meat product

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Commercial (COM) and laboratory (LAB) multivitamin microcapsules were implemented in a standard frankfurter formulation to produce a functional food. The control (CON) treatment consisted of the standard frankfurter formulation. Two trials ($n=20$ /treatment/trial) were evaluated for sensory characteristics and thiamine levels using high performance liquid chromatography (HPLC). Thiamine level was utilized as an indicator of microcapsule viability after thermal processing and subsequent preparation. Treatment did not have an effect on any of the evaluated sensory characteristics in trial A ($P>0.05$). However, display day (dd) aging increased cook loss in Trial A. However, in Trial B, LAB and COM treatments had higher cook-loss ($P<0.0001$) than CON, transversely average initial juiciness scores increased depending on treatment ($P=0.0353$). The average initial and sustained tenderness in trial B was dependent on dd with tenderness increasing throughout the aging intervals ($P<0.0001$, 0.0002, respectively). Flavor intensity and off-flavor were not dependent on treatment or dd ($P>0.05$) for both trials. In Trial A, overall acceptability was affected by dd ($P=0.0004$). In Trial B, there were no differences in overall acceptability of products ($P>0.05$). Multivitamin microcapsule treatments did not have an effect on sensory characteristics when added to a ready-to-eat meat product. Thus, multivitamin microcapsules may be added to frankfurter formulations to increase functional properties without adverse affects on sensory properties.

Keywords: Multivitamin, Microcapsule, Sensory

Goat meat properties in overwrap packaging and high oxygen, carbon monoxide, and anoxic modified atmosphere packaging

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Goat meat has lower fat and higher unsaturated fatty acid content than other red meats. Most shelf life properties of meat are extended by modified atmosphere packaging (MAP), but MAP with oxygen (O_2) may promote oxidation of lipids and pigments. Addition of carbon monoxide (CO) can enhance meat color. Few studies have examined goat meat in MAP and no studies were found on goat meat in MAP with CO. The objective was to determine properties of goat meat in MAP compared with air-permeable overwrap packaging through 21 d of 2 °C storage. *Semimembranosus* muscles from the right sides of 13 kid goat meat carcasses were cut into 1.25-cm thick slices at 24 h postmortem and randomly assigned to 80% O_2 :20% CO_2 , 80% N_2 :20% CO_2 , 69.65% N_2 :29.85% CO_2 :0.5% CO MAP or overwrap packaging and stored in the dark. *Semimembranosus* muscle was selected as the

largest muscle in the goat carcass that would give 8 slices (average 30 g each) for duplication of each packaging treatment. Three packages of each treatment (air permeable polyvinylidene chloride (PVDC) film and polyfoam trays for overwrap and barrier lidding film and barrier trays for MAP) were analyzed for pH, color, % drip loss, aerobic plate counts, and lipid stability at 3 d intervals. The pH was measured with a probe electrode and portable meter (Model 2000 VWR Scientific), color with a Minolta spectrophotometer (Model CM-508 d portable with an 8 mm aperture, 10° observer angle, D65 illuminant source), aerobic plate counts with Petrifilm, drip loss as a percentage of initial weight, and lipid oxidation as thiobarbituric acid (TBARS) by aqueous extraction. The pH increased in all samples in the first week, and *Semimembranosus* in PVDC overwrap had the highest ($P < 0.05$) pH. *Semimembranosus* in PVDC overwrap had highest ($P < 0.05$) % drip loss compared with MAP treatments during 21 d. Aerobic bacteria counts decreased by 0.1–0.5 log cfu/g with MAP while counts for goat meat in PVDC increased ($P < 0.05$) 0.5 log cfu/g during 21 d. The 69.65% N₂:29.85% CO₂:0.5% CO MAP treatment had the lowest aerobic plate count. TBARS values for all treatments increased ($P < 0.05$) with storage time, but were lowest ($P < 0.05$) in anoxic MAP (80% N₂:20% CO₂) than in other packaging throughout the 21 d. *Semimembranosus* in overwrap packaging had lowest ($P < 0.05$) L* lightness and highest ($P < 0.05$) a* redness. Addition of 0.5% CO resulted in enhancement of *Semimembranosus* meat color while goat meat in anoxic MAP had the lowest lipid oxidation. Bacteria growth was decreased in MAP with CO₂. Fresh goat meat appeared to have similar responses to overwrap and different types of MAP packaging during refrigerated storage as most other red meats.

Keywords: Goat meat, Packaging, Shelf life

Functional properties of a myofibrillar protein and commercial pea protein mixture as affected by ionic strength and microbial transglutaminase

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Various plant proteins have been studied as extenders in processed meat formulations and related information is mostly available on soy and wheat proteins. Despite nutritional advantages and worldwide production, pea protein (PP) has limited use in processed meat products. The aim of this study was to evaluate the effects of ionic strength and microbial transglutaminase (TG) on the functional properties of PP and porcine myofibrillar protein (MP) and to provide a better understanding on the role of PP in processed meat formulations. The MP, extracted by low ionic strength phosphate buffer (pH 6.5, I = 0.18), was washed repeatedly with 8 vol. of water (pH 6.5) until the NaCl content of MP reached below 1 mM and used as the zero-ionic strength MP source. Commercial PP (82% total crude protein) was donated by Nutri-Pea Ltd. (Propulse, Portage La Prairie, MB, Canada). For the preparation of MP and PP stocks, zero (I = 0), low (I = 0.05) and high (I = 0.53) ionic strength buffer (pH 6.5) were selected and the targeted protein concentration (1% for solubility and emulsion properties, 0.04% for turbidity measurement) was adjusted by diluting the stock with solutions of desired ionic strength. The protein mixture (MP + PP) was prepared by mixing MP and PP stocks at 1:1 (w/w). Fresh TG preparations (Activa TG-TI, Ajinomoto USA, Fort Lee, NJ, USA) were made in respective ionic strength buffer. The TG-treated protein suspensions (protein:enzyme preparation 2:1, w/w) were incubated at 4 °C for 24 h with the exception of the dynamic rheology study in which 4% protein was reacted with 0.5% TG without incubation. A 20% corn oil-in-water emulsion stabilized by 1% protein

with or without 0.5% TG was prepared to characterize emulsion properties. On the basis of functional properties of proteins, the MP was definitely ionic strength-dependent, i.e., the MP was soluble at zero and high ionic strength (>90%) while it was insoluble at low ionic strength (<10%). The interaction of TG with MP was obvious at high ionic strength, where the TG-treated MP showed better gelling ability than untreated. Although ionic strength did not affect solubility of commercial PP (ca. 30%), interaction of PP and TG was best at low ionic strength where the TG-induced cross-linking of PP was rapid. The differences between the responses to ionic strength and TG by MP and PP affected the functionality of the protein mixture. The solubility maximum of the protein mixture was found at high ionic strength and low ionic strength resulted in lower solubility than zero-ionic strength ($P < 0.05$). Although commercial PP showed a hindering effect on heat-set MP gelation, PP improved emulsion characteristics of MP. From a MP gelation point of view, the addition of TG promoted cross-linking between MP and PP, hence forming a heat-set gel of the protein mixture at high ionic strength in particular. This study suggested that application of commercial PP has no negative effect on the key functionalities of MP, while the combination of PP with TG has potential as an effective meat binder.

Keywords: Pea protein, Microbial transglutaminase, Ionic strength

Evaluation of tomato powder on physicochemical properties and antioxidant activities of regular-fat sausages during refrigerated storage

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This study was performed to evaluate the antioxidant and antimicrobial effects of oven-dried tomato powder (TP) on emulsified pork sausages. The control (without TP), reference (butylated hydroxytoluene, BHT 0.01%), and 2 levels (1 and 2%) of TP were prepared. pH values and Hunter L value of pork sausages formulated with TP were reduced, while Hunter a and b values were higher than those of the control and those effects were increased with increased levels of tomato powder. During storage at 10 °C under the over-wrap packaging for 28 d, pH and Hunter L values were slightly increased, however, no differences in proximate composition, expressible moisture content, textural and sensory evaluation and total plate counts were observed among all treatments ($P > 0.05$). However, thiobarbituric acid reactive substances (TBARS) values of pork sausages containing TP were lower than that of the control and reference, regardless of TP levels. These results indicated that TP could be used as a natural color agent and antioxidant in meat products.

Keywords: Tomato powder, Antioxidant activity, Emulsified pork sausage

Effect of different non-meat proteins and incubation times on gelling properties of pork myofibrillar protein gels

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Red bean protein has been reported to have the high lysine content and might likely be the substrate for transglutaminase (TGase), which catalyze the protein cross-linking through the covalent bond. This reaction has also been used to improve gel strength of various protein gels including meat protein system. Therefore, this study was to determine the potential possibility to replace soy protein isolate (SPI) with red bean protein isolate (RBPI) on gel properties of myofibrillar

protein (MP) in the presence of microbial TGase. In first experiment, pork MP gels were prepared with 0.45 M salt and effect of 2 types (SPI vs RBPI) and various levels (0.1, 0.3, 0.5 and 1%) of non meat protein (NMP) on gelling properties were investigated. Although the type of NMP did not affect the gel strength ($P \geq 0.05$), but increased level of NMP increased the cooking yields (CYs). In addition, RBPI had higher CYs than SPI at the level of higher than 0.5%. In 2nd experiment, effect of 2 types of NMP (0.1%) and MTG (0.1%) with various incubation times (0, 4, 8, 10, and 12 h) on gel properties were also measured. MP gel strength at 10 h was harder than those with lower incubation times (≤ 10 h). CYs of MP gel with RBPI (0.1%) had higher than those with control (CTL) and SPI. These results indicated that addition of NMP increased CY, as compared with the CTL, regardless of incubation time. Sodium dodecyl sulfate PAGE (SDS-PAGE) indicated that incubation at 10 h allowed TGase to catalyze cross-linking of MP and RBPI or SPI through the covalent cross-linking. The protein patterns of MP gel (after cooking) on SDS-PAGE revealed that TGase catalyzed myosin heavy chain cross-linking during cooking. These results suggested that RBPI would likely be a good substrate for TGase to improve textural properties of meat protein gel and the optimum incubation time was found to be approximately 10 h at RBPI (0.1%) induced by TGase.

Keywords: Myofibrillar protein, Red bean protein isolate, Transglutaminase

Effect of packaging method on the shelf-life of meatball made from sucuk dough

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Turkish style meatballs (koefte) are produced mainly from ground meat (beef and/or lamb), fat (beef fat and/or lamb tallow fat), various spices and/or moistened bread and called by different names depending on the local area. Turkish sucuk is a fermented meat product and is produced by thoroughly mixing ground beef, beef fat and certain spices. Then, the resultant sucuk dough is put into natural or artificial casings and aged at certain relative humidity and temperature. Since Turkish sucuk is a highly demanded meat product, innovative processed meat products from sucuk dough such as sucuk doner and sucuk meatball are produced. In this study, the effects of different packaging methods namely aerobic packaging (AP), vacuum packaging (VP) or modified atmosphere packaging (MAP, 65% N₂ and 35% CO₂) on the shelf life of sucuk meatballs were investigated. Microbiological, physicochemical and sensory properties of sucuk meatballs stored at 4 °C were evaluated. The 2-thiobarbituric acid reactive substances (TBARS) increased with storage time with the highest increase observed for samples packaged with AP and with the lowest increase observed for those packaged with MAP. Lightness (L*) and redness (a*) values for all samples decreased ($P < 0.05$) with storage time and MAP preserved color better than AP or VP. The highest microbial counts were determined for samples packaged in AP, while the lowest microbial counts were determined for samples packaged in MAP ($P < 0.05$). Samples packaged in AP and VP reached the spoilage limit (7 log cfu/g) on the 15th and 21st days of storage, respectively. However, samples packaged in MAP did not reach this spoilage limit. Sensory analysis showed that sucuk meatballs packaged in MAP were given higher sensory ratings than those packaged in VP or AP. Therefore, microbiologically, shelf-life of sucuk

meatballs stored in AP was about 15 d, while samples packaged in VP had a shelf life up to 21 d. Samples packaged in MAP were still microbiologically acceptable and palatable after 30 d of storage. Therefore, MAP can be sued as a preferred choice of packaging for sucuk meatballs.

Keywords: Meatball, Sucuk, Packaging

Effect of dried fruit seed powders on color stability of ground turkey meat

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The objective of this study was to evaluate the effect of novel inclusion of fruit seed powders with high antioxidant phytochemical concentrations, in white, dark, and 1:1 composite blend blocks of ground turkey meat on objective color characteristics. Two hundred 205 turkey hens of the same age and diet were humanely harvested at the University of Minnesota Meats Laboratory. Breasts and thighs were removed from a random subset of turkeys ($n = 90$) 24 h post mortem, vacuum packaged, and stored frozen. Turkey breast white meat and turkey thigh dark meat was tempered to refrigerated temperature for 48 h and uniformly ground by type into 27 kg batches. White and dark meat batches were divided in half with one portion from each batch being blended for a 1:1 composite meat block, for a total of 3 batches (white, dark, and composite). Each batch was divided and assigned randomly to one of 4 seed powder antioxidant treatment groups to be arranged in a 3 × 4 factorial design: control with no added seed powder (CON); cranberry seed powder (CRAN); grape seed powder (GRAPE); and raspberry seed powder (RASP) for a total of 12 treatment groups. Seed powders were added to each treatment batch at 500 ppm and were blended for 5 min. One kg samples of each treatment were placed on trays and overwrapped with polyvinylchloride wrap, with 6 replications per treatment. Ground turkey packages were stored at 4 °C under cool white fluorescent lighting and objective color values (L*, a*, and b*) were taken at 6 locations for each package for 7 d with a Minolta CR-310. CON L* values were highest for both white and dark meat for all 7 d ($P < 0.001$). Additionally, a* values for both white and dark meat indicated differences ($P < 0.001$) between the CON and RASP, and CRAN and GRAPE, with CON and RASP having higher a* values for all days. For white and dark meat blocks, treatment did affect b* values ($P < 0.001$) with the highest values for CON and RASP. L* values for the composite blend were higher for CON compared with CRAN, GRAPE, and RASP ($P < 0.001$). CON b* values for the composite blend were higher ($P < 0.001$) than all seed powder treatments during the entire shelf life period. For a* values in the composite blend, CON and GRAPE were higher ($P < 0.001$) than CRAN and RASP. These results indicate that the addition of seed powders to ground turkey meat did not improve color stability during 7 d of shelf life, however further investigation is warranted.

Keywords: Turkey, Antioxidants, Seed powders

Effects of Noni pulp and juice on Lee-Kramer shear force, cooked color and consumer acceptability of ground beef patties

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The Noni plant (*Morinda citrifolia*) has been used as a homeopathic medicine in Polynesia for hundreds of years due to its antioxidant and analgesic properties. Recently, Noni pulp was successfully incorporated into ground beef patties to improve color stability and inhibit oxidative rancidity in retail display; however, trained taste panelists found the flavor of Noni-incorporated beef patties to be objectionable. The objective of the current study was to determine the effects of Noni pulp and clarified Noni juice (a separate Noni product) on objective tenderness measurements, internal cooked color, and consumer acceptability of beef patties. Ground beef (85% lean) was mixed with 0, 2.5, and 5% Noni pulp or Noni juice to create 5 treatments (5 ground beef batches/treatment) and was formed into 113-g patties, which were subsequently vacuum-packaged and frozen. Patties were thawed overnight at 4 °C and cooked on countertop griddles to 71 °C, turning every 4 min. For Lee-Kramer shear force, patties were allowed to cool to room temperature and a 6.0×6.0-cm section was cut from the center of each patty and sheared with a 6-blade Lee-Kramer shear apparatus attached to an Instron Universal testing machine. Patties, for cooked color measurement, were immediately placed in plastic bags and immersed in an ice-water bath to stop cooking. Then, patties were cut parallel to the surface of the patty and 3 color measurements (L^* , a^* , b^* and spectral reflectance) were taken of the internal surface of the patty using a HunterLab MiniScan. In addition, consumer panelists ($n=150$), who ate beef 3 or more times weekly, were selected from a pool of over 10,000. Patties for consumer testing were seasoned with 0.4-g of Montreal steak seasoning before cutting into 4 samples. Each panelist was given a sample from each treatment in a random order and asked to evaluate overall acceptability, beef flavor, and texture on a 7-point scale, and the presence of non-beef flavor. Juiciness and beef flavor were also evaluated on a 5-point just-about-right scale. Control patties and those with 2.5% juice had greater ($P<0.05$) Lee-Kramer shear force values than 2.5% pulp and both 5.0% Noni treatments. Control patties also tended to be lighter ($P=0.053$) than Noni-incorporated patties, and cooked patties with 2.5% Noni products were redder (greater a^* , $P=0.045$; lower hue angle, $P=0.039$; and greater 630/580 nm ratio, $P=0.051$) than those with 5% Noni products. Patties with Noni juice were more intensely saturated with color (greater chroma, $P=0.021$) than those with Noni pulp. Consumers scored patties with 2.5% Noni similarly ($P>0.05$) to controls for overall impression and flavor, but received greater ($P=0.007$) scores for texture than those with 5% Noni. For the just-about-right scales of beef flavor and juiciness, consumers did not detect differences ($P>0.05$) between control and Noni patties. Consumers also detected the presence of off-flavors more often in Noni patties than in controls ($P=0.0013$), and more often in the 5% patties than in the 2.5% Noni patties ($P<0.0001$). Noni incorporation was shown to decrease Lee-Kramer values, but consumers evaluated Noni-incorporated patties as less acceptable in texture. Furthermore, the 2.5% Noni patties had similar flavor and texture attributes to controls.

Keywords: Noni, Ground beef, Cooked color

Effects of mixing time and a buffered vinegar/lemon juice concentrate on textural and sensory traits of cooked natural roast beef and turkey rolls

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The effects of mixing time on the quality of natural roast beef and turkey rolls formulated with or without buffered vinegar and lemon juice concentrate were evaluated. Natural oven roasted turkey and roast beef treatments were formulated with 1.5% sea salt, 0.5% turbinado

sugar and 0% (control; C) or 2.5% buffered vinegar and lemon juice (LV). During processing, turkey products were mixed for 5, 10, 15, or 20 min, while beef was mixed for 2.5, 5, 10, 15, and 20 min. Mixing time had no effect on cooking yield of either turkey or beef rolls. As mixing time increased, L^* (lightness) values increased ($P<0.05$) for beef and turkey, and a^* (redness) values decreased ($P<0.05$) for beef rolls. Twenty minutes of mixing made the beef product springier ($P<0.05$) than 2.5, 5, or 15 min. Consumer sensory panels rated beef mixed for 20 min tougher and drier ($P<0.05$) than 2.5, 5, and 10 min mix time. Beef rolls with 2.5% LV had a greater ($P<0.05$) cooking yield than C beef rolls. HunterLab L^* and a^* values for turkey roll slices were lower ($P<0.05$) for LV treatments than for C. LV treated turkey samples were rated higher ($P<0.05$) for sweetness, saltiness, tartness, and lingering of aftertaste by sensory panels; however, C had a higher ($P<0.05$) turkey flavor rating. Beef LV treatments were rated higher ($P<0.05$) for sweetness, tartness, lingering of aftertaste and overall flavor. An interaction ($P<0.05$) between mixing time and treatment was found for b^* values and hardness for beef slices. Mixing time can affect color and texture as increasing mixing time makes the final product lighter for slices of beef and turkey and also decreases redness in beef. Mixing beef for more than 15 min can make the product tougher and drier. The addition of LV slightly increases product lightness and reduces product redness, especially in medium rare roast beef slices. However, the addition of LV can also enhance flavors in turkey rolls. Processors will need to critically evaluate mixing time and LV addition to natural beef and turkey products.

Keywords: Mixing time, Beef, Turkey

The effect of kiwi juice injection on the palatability and retail color of eye of round steaks from cow carcasses

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Retail cuts originating from the chuck and round are generally tougher and more variable in tenderness than cuts from the rib and loin. Also, beef products from cattle of advanced maturity are tougher, due to the decreased solubility of connective tissue. Actinidin is a cysteine protease enzyme found abundantly in kiwi juice and has been shown to improve cooked meat tenderness when injected at 10% of the injection solution. The purpose of this study was to determine the effect of injecting kiwi juice into beef eye of round muscles from cow carcasses on traits evaluated by a trained panel, Warner-Bratzler shear (WBS) analysis, and retail color acceptability. A pilot experiment was performed with eye of round roasts using a single needle injector to inject a 10% kiwi juice solution (83.5% water, 3.5% salt, and 3.0% phosphates) to 110% of the initial meat weight. After injection, the meat was vacuum packaged and held for 7 d. At the conclusion of the 7 d holding period the product was denatured too extensively for testing, indicating that brine containing 10% kiwi juice is too excessive for optimal tenderization, thus injection levels were modified for the primary experiment. At 3 d postmortem, 2 steaks were fabricated from the center of pairs of beef semitendinosus muscles ($n=10$) from USDA Commercial carcasses, to serve as a negative control (NCON) for sensory and WBS analysis. One roast from each muscle was multi-needle injected to 110% of its initial weight with a control solution (CON; 93.5% water, 3.5% salt, and 3.0% phosphates) and the other roast from each muscle was injected with a solution with the same ingredients plus 2.5% or 5% kiwi juice in substitution for water. All samples were vacuum packaged and aged for 7 d. Steaks ($n=3$) were then fabricated from the medial portion of each injected semitendinosus muscle. Steaks assigned to sensory and WBS were frozen, while steaks assigned to shelf life evaluation were placed in Styrofoam trays, overwrapped with PVC film

and placed in coffin display cases where the cuts were objectively and subjectively evaluated daily. Sensory panelists found NCON steaks were tougher and had more connective tissue ($P < 0.0001$) than CON or kiwi injected steaks which did not differ ($P = 0.14$) for sensory tenderness or connective tissue. Panelists found CON steaks had higher juiciness scores ($P = 0.01$) than steaks with 5% kiwi juice added. Panelists found NCON steaks to be less salty ($P < 0.0001$) than CON steaks, with kiwi injected steaks being intermediate for saltiness. No differences ($P \geq 0.33$) were noted between treatments for thaw or cooking loss, off flavor, or beef flavor intensity. NCON steaks tended ($P = 0.075$) to have greater WBS values than steaks injected with 5% kiwi juice, but all steaks fabricated from injected muscles were similar for WBS. Steaks injected with CON solution had whiter ($P = 0.005$) subjective fat color scores than kiwi juice injected steaks after 2 d of retail display. No other differences were found between injection treatments for subjective or objective measurements of color on the same retail display day. These results suggest that palatability and retail color of products injected to 110% of initial weight with a solution containing 2.5 or 5% kiwi juice did not differ from those injected with the control solution.

Keywords: Kiwi, Actinidin, Tenderness

Controlling pink color defect in cooked turkey product using a dehydrated whey protein concentrate

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Pink color defect affects cooked, uncured poultry products, causing them to appear uncooked and rendering them undesirable in consumers' eyes. Previous research has demonstrated that citrate, lactoferrin, and calcium independently have the potential to reduce this pink color defect. These constituents can be found in various levels in commercially produced whey protein-based concentrates. A whey protein concentrate (WPC) known to contain these constituents was selected for its ability to reduce the pink color defect in a ground turkey breast model containing known pink generating ligands. Pink color-generating ligands (PGL) were incorporated to determine if this WPC was able to prevent the pink color from occurring. Four treatments (replicated 3 times) were included in this study: a control (C) and 3 treatments (TRT). C served as the base formulation for all TRTs and contained ground turkey breast, water (20%), salt (2%), and sodium tripolyphosphate (0.5%); TRT1 contained 2% added WPC; TRT2 contained 2% added WPC and 1% nicotinamide; and TRT3 contained 2% added WPC and 10 ppm sodium nitrite. Nicotinamide and sodium nitrite were added to induce a pink color in the turkey breast. All above ingredients were added on a meat weight basis. Addition of WPC increased ($P < 0.0001$) CIE L^* (lightness) in all TRTs compared with C, while CIE b^* (yellowness) values were decreased in TRT2 and TRT3 ($P < 0.0001$) compared with C and TRT1. CIE a^* , an indicator of redness, was similar ($P > 0.05$) in C (1.27) and TRT1 (1.10); however, the addition of PGL increased ($P < 0.0001$) a^* values in TRT2 (3.42) and TRT3 (3.86). Therefore, the inclusion of WPC in TRT2 and TRT3 was not able to reduce the CIE a^* to the same level as either the C or TRT1. C and TRT1 also showed a decreased ($P < 0.05$) chroma value compared with TRT2 and TRT3. The pigments, nitrosylhemochrome (rNIT) and nicotinamide hemochrome (rNIC), were also studied using spectrophotometric analysis (%R650 nm/%R570 nm, %R537 nm/%R553 nm; respectively, lower value less pigment). C and TRT1 had lower ($P < 0.05$) rNIC values compared with TRT2 and TRT3. Further, C and TRT1 had lower ($P < 0.05$) rNIT values compared with TRT2 and TRT3. PGL in TRT2 and TRT3 caused a significant rise in their respective pigment. rNIC was highest ($P < 0.05$) in TRT2, the TRT containing nicotinamide as a PGL; rNIT was highest ($P < 0.05$) in TRT3, which contained sodium nitrite as part of its

formulation. All TRTs demonstrated a higher ($P < 0.0001$) percentage cook yield compared with C. There were no differences ($P > 0.05$) in precook pH. In addition no differences in pH were found in the cooked turkey. The lack of pink color inhibition by this WPC could be the PGLs were added at a level too high for any control to be determined. In white muscle poultry, endogenous nitrite or as an exogenous contamination at a level 1–3 ppm has been found in commercial conditions. Since this WPC did not decrease the pink defect as reported with some other WPCs, this WPC may have potential if lower, more subtle levels of PGL are evaluated.

Keywords: Turkey, Pink color defect, Whey protein concentrate

Effects of sea salt on the tenderness and color of beef loin steaks

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As the most common curing ingredient for meat products, salt has been known for enhancing meat palatability. Effect of salt on meat tenderness has also been documented, which can be used as an inexpensive value-adding mechanism for meat cuts. The objective of this study was to determine the effect of sea salt on Warner Bratzler shear force (WBSF) and instrument color of beef strip loin steaks. The study was conducted in 2 separate experiments. In the first experiment, 32 strip steaks (2.54-cm thickness and 0.3-cm external fat) from 4 USDA Select strip loins (8 steaks per loin) purchased from a local market (Lubbock, TX) were randomly (within each loin) assigned to either control (CO1) or one of the 3 following treatments ($n = 8$): application of 6 g of sea salt to both sides of the steaks (SS1), application of 6 g of sea salt and 6 g of ground fresh garlic to both sides of the steaks (SSFG), and application of 6 g of sea salt and 4 g of powder garlic to both sides of the steaks (SSPG). All steaks in experiment 1 were allowed to rest for 2 h before analysis. The second experiment followed the same experimental design with 32 steaks from 4 USDA Choice strip loins that were randomly assigned to either control (CO2) or one of the following 3 treatments ($n = 8$): application of 12 g of sea salt to both sides of the steaks (SS21) for 1 h, resting the steaks on a layer (0.5 cm) of sea salt for 1 h (SS22), and resting the steaks in sealed vesicle containing a layer (0.5 cm) of sea salt but without direct contact with the salt for 24 h (SS23). The treated steaks in experiment 1 were rinsed with water and dried with a paper towel after the 2-h resting period, whereas those in experiment 2 were brushed to remove visible salt crystals after their respective treatment application period. The steaks were subsequently subjected to instrumental color and WBSF analyses. Results from experiment 1 indicated sea salt decreased WBSF of steaks ($P < 0.001$) compared with CO1, except when combined with fresh garlic ($P = 0.655$). The WBSF values for SS1 and SSPG were 2.28 and 2.45 kg, respectively, with CO1 and SSFG yielding WBSF values of 2.95 and 3.03 kg, respectively. In experiment 2, SS21 and SS22 had similar WBSF compared with CO2 (3.47 to 3.70 kg; $P = 0.341$ to 0.874). However, SS23 decreased WBSF (2.69 kg; $P < 0.001$) compared with CO2, SS21, and SS22. The application of sea salt decreased the lightness and redness of steak lean surface in both experiments ($P < 0.001$), although the effect was more profound in experiment 1 when garlic was used (a^* values of 3.69 and 5.36 for SSFG and SSPG vs. a^* values of 15.40 and 8.06 for CO1 and SS1, respectively; $P < 0.001$). In experiment 1, the 3 sea salt treatments yielded 3% lower cook losses (20.14 to 21.21%) compared with CO1 (24.79%; $P < 0.001$). In experiment 2, SS22 had lower cook loss than CO2, SS21, and SS23 (20.77% vs. 22.19 to 23.36%; $P = 0.015$). The application of sea salt can be a simple method to increase tenderness; however, further investigation is needed to determine the optimal salt concentration and the method of applying salt to meat cuts. Although the change in color of steak lean surface may limit application, the

enhanced palatability may overcome this limitation in a foodservice setting.

Keywords: Sea salt, Beef loin steak, Tenderness

Determining the yield, proximate composition, and color characteristics of trimmings from hot processed and traditionally processed cull doe goats

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The objective of this study was to identify the yield, composition, and color attributes of trimmings from hot processed and traditionally processed cull meat goats. Crossbred cull doe goats ($n=18$) were purchased from a livestock sale facility in Yates Center, KS and transported to the Kansas State University Sheep and Goat Teaching Facility. Six randomly selected goats were harvested at the Kansas State University Meat Laboratory on 3 separate days. After slaughter, evisceration, and splitting, one side of each carcass was randomly assigned to either a hot processed (HP) or traditionally processed treatment (TP). The mean live weight of the goats immediately before slaughter was 41.0 kg with a range of 22.0–64.0 kg. The mean carcass side weight for the HP and TP sides was 8.6 and 8.8 kg respectively. Sides from the HP treatment were fabricated, ground with 2% NaCl, and chilled with the addition of dry ice to reach 2 °C within 2 h following exsanguination. After chilling the HP trimmings were held at 2 °C until sampling occurred 24 h postmortem. TP carcass sides were conventionally chilled at an ambient air temperature of 2 °C before fabrication. TP carcasses were fabricated 24 h postmortem and then ground and mixed with or without the addition of 2% NaCl resulting in 2 traditionally processed treatments (TPNS and TPS, respectively). At 24 h postmortem, samples were taken for pH, trim yield, water holding capacity (WHC), fat, moisture, protein, and instrumental color including lightness (L^*), redness (a^*), and yellowness (b^*). The HP treatment possessed a higher ($P<0.0001$) 24 h pH of 6.30 compared with a 6.06 pH for the TP treatment. There were no differences ($P>0.06$) in the yield of trimmings between the HP treatment (6.35 kg) and TP treatment (6.50 kg). The HP treatments had higher WHC compared with both TPS and TPNS ($P<0.002$) treatments. HP (70.0%) and TPNS (70.14%) treatments had higher ($P<0.001$) moisture content than TPS (68.8%). Fat content was similar ($P>0.19$) for all treatments with mean values ranging from 9.6 to 10.6%. However, TPNS had more protein ($P<0.0001$) than the HP treatment. The TPS treatment had higher ($P<0.05$) a^* values compared with HP and TPNS treatments. Finally, the HP treatment had lower ($P<0.05$) a^* and b^* values compared with the traditionally processed treatments. In summary, differences in processing techniques did not result in differences in trim yield, moisture or fat content. Hot processing increased 24 h pH and WHC. Furthermore, hot processing decreased redness and yellowness of trimmings from cull goat carcasses compared with traditional chilling and processing techniques.

Keywords: Goat, Hot processed, pH

Extraction of salt-soluble proteins in meat is affected by species and muscle type

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When forming a meat emulsion, salt-soluble myofibrillar proteins are the main contributors to the matrix followed by sarcoplasmic proteins. The quantity and functionality of these proteins are dependent

on factors such as species, sex and age of the animal, as well as pre-slaughter and post-mortem treatment. The purpose of this experiment was to quantify the amount of salt-soluble proteins in various muscles of 3 species commonly used in meat products - beef, pork, and chicken. The study was designed as a complete randomized design in a 2×3 factorial arrangement. The factors for this experiment were muscle type (light and dark) and species (beef, chicken and pork). Pork and beef samples were whole muscles, serratus ventralis (dark) and semitendinosus (light), which are commonly utilized as trim for further processing. Chicken samples were pectoralis major muscle (light) and the entire thigh (dark). In all, there were 5 independent samples from each muscle type for all 3 species ($n=30$). Meat was trimmed of external fat, homogenized, vacuum packaged and stored at -29 °C until analyses were conducted. Samples were analyzed for proximate composition and salt-soluble protein content at salt (NaCl) concentrations of 0%, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%, 3.5%. Data were expressed as the percentage of salt soluble proteins on a solids (weight minus fat and moisture) basis due to differences in fat content between muscles and species. Data were analyzed using the mixed procedure of SAS with a model including the main effects of species, muscle type, salt and their interactions. Means were separated using the PDIF option. Overall, chicken showed greater protein extraction ($P<0.001$) than beef and pork, which were equal to each other. At all salt concentrations, chicken light muscle showed the greatest extractability for all muscle type and species combinations. There were no differences between muscle types for pork or beef. However, chicken light muscle had higher values of extractable proteins compared with chicken dark muscle ($P<0.001$) at all salt concentration levels. This study suggests that the use of chicken in further processed products could reduce the amount of salt needed as adequate levels of extractable proteins are achieved in chicken muscles at lower salt concentrations when compared with beef and pork.

Keywords: Salt, Protein, Extraction

Antibacterial activity of essential oils of two thymus species in meat homogenates

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The presence and growth of bacteria in meat and meat products may cause spoilage. Indeed, it can cause food-borne illnesses. A range of synthetic agents have been used to inhibit the bacterial growth in meat products, although concerns about the safety of these chemicals have increased consumer demand for natural food products. Essential oils (EOs) obtained from many plants have recently gained in popularity and excited scientific interest. The antimicrobial properties of aromatic plant essential oils have been widely assessed in a wide variety of foods. The aim of this study was investigated the effectiveness in vitro of the EOs from 2 species of thymus such as *Thymus moroderi* and *Thymus piperella* on growth of selected food-borne indicators as *Aeromonas hydrophila* and *Listeria innocua* in homogenate meat products (minced meat, dry-cured meat and cooked meat). Ten grams of different meat products were added to 90 mL of water and homogenized in a Stomacher until smooth. The agar disc diffusion method (ADDM) was used to determine the antibacterial activities of the essential oils. A suspension (0.1 mL of 106 cfu/mL) of each microorganism was spread on the meat homogenates medium plates. Filter paper discs (9 mm) were impregnated with 40 μ L of the each EO and placed on the inoculated plates; these plates were incubated at 37 °C for 24 h. The concentration effect (CE) was studied for to ascertain which doses (40, 20, 10, 4 and 2 μ L) of essential oil had an inhibitory effect on bacterial growth. All tests were performed in triplicate. In minced meat, the ADDM indicated that

T. piperella EO showed ($P < 0.05$) the highest antibacterial activity against the 2 bacteria tested, with inhibition zones ranging from 25.00 mm on *L. innocua* and 32.00 mm on *A. hydrophila*. In the case of *T. moroderi* EO showed ($P < 0.05$) inhibition zones of 14.00 and 15.00 mm for *L. innocua* and *A. hydrophila* respectively. For dry cured meat, any of the 2 EOs did not show ($P > 0.05$) inhibitory capacity against the bacterial strain tested. Regarding cooked meat *T. piperella* EO present higher antibacterial activity ($P < 0.05$) than *T. moroderi* EO. For *L. innocua*, *T. piperella* produced an average zone of inhibition of 20.5 mm, while *T. moroderi* was non active. For *A. hydrophila*, *T. moroderi* and *T. piperella* showed ($P < 0.05$) inhibition zones of 18.00 and 25.00 mm respectively. Regarding to CE, in minced meat, *T. piperella* EO showed ($P < 0.05$) inhibitory effect, in all added concentrations, for both, *A. hydrophila* and *L. innocua*, while *T. moroderi* EO did not show inhibitory effects at lower concentrations. In dry cured meat any of the 2 EOs studied did not show inhibitory effects in any added concentrations for the 2 strain tested. In cooked meat the *T. piperella* EO showed inhibitory effects ($P < 0.05$) in all added concentrations, except the lowest for both, *A. hydrophila* and *L. innocua*. *T. moroderi* EO did not present ($P > 0.05$) inhibitory effect in all concentrations added for *L. innocua*. In the case of *A. hydrophila* it showed inhibitory zones at higher concentrations. In summary, the essential oils of *T. piperella* and *T. moroderi* can be used to control the growth of bacteria related with the food spoilage in a variety of meat and meat products.

Keywords: Essential oils, Antibacterial, Meat products

Growth of biophotonic *Escherichia coli* O157:H7 (ATCC #43888) within rumen fluid media

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The use of biophotonic microbes can allow researchers to gain a better understanding of mechanisms utilized by bacteria to grow and colonize within the ruminant gastrointestinal tract, thus allowing the investigation of how stress management and nutrition impact pathogen shedding in ruminants. However, before biophotonic bacteria can be introduced into an animal model, it is imperative to characterize the growth of the bacterium in relation to its non-transformed wild-type (WT) strain to validate the model. The goal of this study was to characterize the growth of the *Escherichia coli* O157:H7 (ATCC 43888) strain transformed with the pAK-1 biophotonic plasmid against that of the WT in rumen fluid medium. Rumen contents obtained from a cannulated Holstein steer were filtered (Leyendecker et al., 2004) and added to the rumen medium (Russell and Martin, 1984). Cultures of the ATCC 43888 WT and pAK-1 biophotonic strain were allowed to grow to mid-log phase ($OD_{600} \sim 0.5$) at 37 °C in tryptic soy broth. Cultures were then diluted 1:100 in 30 mL of rumen fluid media and incubated at 140 rpm at 37 °C for 48 h. Aliquots of each culture were obtained after 1, 2, 3, 4, 5, 6, 7, 8, 18, 24, and 48 h of growth in the rumen fluid medium. At each time interval, the WT and pAK-1 biophotonic strain were serially diluted in 1X phosphate buffer solution. Aliquots from WT were plated in duplicate on tryptic soy agar (TSA) and aliquots from the pAK-1 biophotonic strain were plated in duplicate on TSA and TSA + ampicillin (amp; 30 µg/mL). Plates were analyzed after 12 h incubation at 37 °C. There was no main effect ($P > 0.05$) between the growth kinetics of the WT and the pAK-1 biophotonic strain during the 48 h growth period. Maximum bacterial concentrations were achieved at 18 h post inoculation: 1.1×10^8 cfu/mL (WT), 7.4×10^8 cfu/mL (pAK-1 on TSA-

amp), and 6.4×10^8 cfu/mL (pAK-1 on TSA). After 48 h of growth in the rumen fluid medium, both the WT and pAK-1 biophotonic strain had significant reductions in growth in comparison to 18 h of growth ($P = 0.09$). No significant differences ($P > 0.05$) were observed for the pAK-1 biophotonic strain between growth on TSA or TSA + amp, indicating that the plasmid was stable for the 48 h growth period in rumen fluid. Additionally, this study indicates that the presence of the pAK-1 plasmid does not impede nor influence the ability of the ATCC 43888 strain to grow in rumen fluid. These results indicate that the concept of biophotonically transformed *E. coli* O157:H7 can be a viable tool for characterizing the colonization and growth of *E. coli* in the gut of ruminants in vitro and in vivo.

Keywords: *Escherichia coli*, Biophotonics, Rumen fluid media

Effect of intrinsic factors on growth of *Listeria monocytogenes* in sliced deli turkey roast

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Intrinsic factors have an impact on the growth of *Listeria monocytogenes* in ready-to-eat meat and poultry products. The growth of *L. monocytogenes* was determined in sliced turkey deli roast formulated with in-going concentrations of 1.5% sodium chloride (NaCl) or 0.75% NaCl and 0.75% potassium chloride, 0 ppm or 200 ppm sodium nitrite ($NaNO_2$), and using 10% or 45% pump for a total of 8 treatment combinations. Turkey deli slices were inoculated with a 5-strain *L. monocytogenes* cocktail or peptone water (control), vacuum packaged and stored at 4 °C. Treatments were sampled on d 0, 7, 14, 21, 28, 42, 63, and 91 of storage to determine *L. monocytogenes* mean log growth enumerated using modified oxford media, and aerobic plate count (APC). The pH, water activity (a_w), nitrite concentration, and percent fat, moisture, protein, and salt were measured using control treatments on each sampling day. There was a nitrite by day interaction ($P < 0.05$) and a percent pump by day interaction ($P < 0.05$) for *L. monocytogenes* and APC mean log growth (cfu/cm²). *L. monocytogenes* populations were reduced by 0.5 to 2.25 log cfu/cm² from d 7 through 91 of 4 °C storage with inclusion of 200 ppm $NaNO_2$ vs. 0 ppm $NaNO_2$. Using 10% pump reduced *L. monocytogenes* populations by 0.5 to 1.5 log cfu/cm² from d 7 to 28 and at d 63 compared with 45% pump. APC populations were 0.75 to 3.0 log cfu/cm² lower from d 7 through 91 of 4 °C storage with inclusion of 200 ppm $NaNO_2$ vs. 0 ppm $NaNO_2$. Using 10% pump reduced APC populations by 1.25 to 2.6 log cfu/cm² from d 7 to 91 compared with 45% pump. Salt type did not affect *L. monocytogenes* or APC growth ($P > 0.05$) during 91 d of 4 °C storage. Water activity was 0.966 to 0.979 and was lower ($P < 0.05$) for treatments with 10% pump compared with 45% pump. Moisture content in treatments with 10% pump was similar ($P > 0.05$) with a mean 73.5% moisture, however, there were differences ($P < 0.05$) in moisture content among treatments with 45% pump. These ranged from 77.5% to 78.7%. Percent protein in treatments with 45% pump was similar ($P > 0.05$) with a mean 15.3% protein, however, there were differences ($P < 0.05$) in percent protein among treatments with 10% pump, ranging from 17.9% to 19.2%. Percent salt was different ($P < 0.05$) among treatments and ranged from 1.78% to 2.56%. There was no ($P > 0.05$) treatment interaction for percent fat which averaged 0.67% or pH which averaged 6.2. Growth of *L. monocytogenes* and APC is influenced by nitrite concentration and percent pump, while inclusion of NaCl or NaCl and KCl did not affect *L. monocytogenes* growth during refrigerated storage in sliced deli turkey.

Keywords: *Listeria monocytogenes*, Turkey, Intrinsic factors

Inhibitory effect of Provian (a co-spray dried mixture of sodium lactate and sodium acetate) on the growth of *Listeria monocytogenes* in low-sodium frankfurters stored at 4, 7, or 10 °C

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Powdered additives have many advantages compared with liquids in handling, mixing, storing, and shipping. This research aimed at evaluating the effect of Provian powder (PP, a co-spray dried mixture of sodium lactate and sodium acetate), Provian D (PD, a mixture of Provian and sodium diacetate) from Kemira Chemsolutions b.v., Netherlands, and one liquid inhibitor on *Listeria* inhibition, organoleptic quality, and physicochemical properties of frankfurters. In each of 3 replications, 4 batches (22.7 kg/batch) of low sodium frankfurters (1.0% salt addition) were prepared according to the following formulations: control (no inhibitors), 1% PP, 0.65% PD, and 2.5% (v/w) of 60% potassium lactate and sodium diacetate (PL-SD), and then dip-inoculated in a 6-strain cocktail of *Listeria monocytogenes*. Growth of *Listeria* and mesophilic aerobic bacteria (MAB) was evaluated at 4, 7, and 10 °C for up to 90 d. The concentration of *Listeria monocytogenes* used was 4 log cfu/g. Using PP, PD and PL-SD, *Listeria* populations increased <2 log cfu/g during 60 and 30 d of storage at 4 and 7 °C, respectively. However, *Listeria* grew to 7 log cfu/g in the control after 15 and 30 d at 4 and 7 °C, respectively, with almost no inhibition seen in any formulations at 10 °C. The same 3 inhibitors suppressed the growth of MAB by 1–2 log cfu/g, compared with the control. No significant differences ($P > 0.05$) were seen in appearance, texture, flavor, or overall acceptability regardless of formulation. Frankfurter containing PP and PD were higher in sodium content than PL-SD and the control. Given these findings along with similar cook yields, Provian powder (PP) appears to provide a viable alternative to liquid (PL-SD) with no negative impact on organoleptic quality.

Keywords: Frankfurter, *Listeria monocytogenes*, Sensory

Decontaminating beef subprimals destined for non-intact products by using combinations of water washing and/or trimming

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Previous research has shown the prevalence of *Escherichia coli* O157:H7 on beef subprimals is low; however, if present, blade tenderization could force pathogens into the muscle. FSIS declares raw, non-intact beef as adulterated if it contains *E. coli* O157:H7. To adequately remove *E. coli* O157:H7 from chilled subprimals, it is imperative to understand how contamination can spread during vacuum packaging. The potential translocation of *E. coli* O157:H7 and the impact of water washing and partial- or full-surface trimming as pathogen reduction strategies were evaluated. Beef top sirloin butts (cap-on and cap-off) were inoculated with 2 levels (high-inoculum at $\sim 10^4$ cfu/cm²; low-inoculum at $\sim 10^2$ cfu/cm²) of a 3-strain cocktail of rifampicin-resistant *E. coli* O157:H7. Following inoculation, subprimals were vacuum packaged and stored for either 0, 14, or 28 d. After storage, the following sites were evaluated: exterior of the bag, purge, inoculation site on the subprimal, area adjacent to the inoculation site, and surface opposite from the inoculation site. Seven treatments then were applied: water wash, water wash followed by full-surface trimming, water wash followed by partial-surface trimming, full-surface trimming, full-surface trimming followed by water wash, partial-surface trimming, and partial-surface trimming followed by water wash. Translocation from the inoculated surface area to other areas of the subprimal was observed. Counts of *E. coli* O157:H7 recovered varied by storage day and cap-on and cap-off subprimals,

but no microbiologically relevant differences were detected. Translocation to other subprimal surfaces could have been caused by purge. *E. coli* O157:H7 levels (high: 4.4 log₁₀ cfu/ml; low: 2.1 log₁₀ cfu/ml) found in purge were similar to initial inoculum levels for both high and low inocula. Contamination was also detected on exterior surfaces of the bags; 12.5% of bags from high-inoculated sirloins were contaminated, as opposed to only 1% of bags from low-inoculated sirloins. Water washing alone had little to no effect on the level of *E. coli* O157:H7 recovered from any subprimal surface, for both high and low inoculated sirloins. Less than a 1.0 log₁₀ cfu/cm² difference was observed between counts recovered before treatment and counts recovered after water washing. Full and partial-surface trimming alone significantly decreased counts recovered from the dorsal surface by 3.0 to 4.0 log₁₀ cfu/cm². However, on the ventral side, full-surface trimming was much more effective than partial-surface trimming; partially trimmed sirloins often had counts at least 0.5 to 1.0 log₁₀ cfu/cm² higher than fully trimmed sirloins. Water washing combined with trimming had little to no additional effect on the counts recovered, with less than a 0.5 log₁₀ cfu/cm² difference often detected between trimming alone and trimming combined with water washing. Of the treatments applied, water washing and partial-surface trimming were the least effective for both high and low inoculated subprimals. Full trimming, with or without water wash, proved to be the most effective treatment used to reduce *E. coli* O157:H7 to non-detectable levels.

Keywords: *Escherichia coli* O157:H7, Beef, Decontamination

The impact of peroxyacetic acid and other novel organic acids as single antimicrobial interventions for the control of *Escherichia coli* O157:H7 in inoculated beef trimmings as measured by traditional plate count and Litmus RAPID-B rapid enumeration

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Ground beef is characterized as a commodity of highest potential risk of food borne illness. Since ground beef is sourced from different cattle and locations, along with the grinding and mixing operations during ground beef production could potentially transfer pathogens to uncontaminated product. In the past decades, *E. coli* O157:H7 has emerged as a high profile food-borne pathogen and frequent ground beef product recalls due to *E. coli* O157:H7 contamination continues to be a serious concern to the US meat industry and consumers. Therefore, our objective was to determine the antimicrobial efficacies of different concentrations of peroxyacetic and other novel food grade organic acids on reduction of *E. coli* O157:H7 on beef trimmings. A model system was developed to mimic a commercial dip treatment system for beef trimmings. Inoculated beef trimmings with *E. coli* O157:H7 (10^5 cfu/g; 25 g/treatment) were processed with antimicrobial treatments by dipping for 15 s in 100 mL solution of peroxyacetic acid (PAA; 100, 150, and 200 ppm) and 3% of novel organic acids [fumaric acid (FA); malic acid (MA); citric acid (CA); gluconic acid (GA); levulinic acid (LA); pyruvic acid (PY); caproic acid (CO), caprylic acid (CL), and capric acid (CP)]. Following antimicrobial treatment, beef trim were spread plated using serial 10-fold dilution in duplicates on aerobic plate count (APC), *E. coli* (EC)/coliform (CO) Petrifilm plates, and via the LITMUS RAPID-B *E. coli* O157 assay. Plated samples were incubated at 37 °C for up to 48 h in an aerobic incubation chamber and the RAPID-B samples were analyzed immediately. Inoculated beef trimmings treated with and without water (IN; IN+W) and un-inoculated (UN) samples served as controls. Among all, CL was most effective in reducing more than

4.78, 4.73, and 2.48-logs of EC, CO, and of APC respectively. The highest concentration of novel organic acid (PY) yielded 1.84, 1.68, and 1.08-log reduction of EC, CO, and APC counts compared with the control (IN + W). Treatment of beef trimmings with PAA, CA, LA, and CP resulted in ~0.3 to 0.5 log reduction of EC and CO and APC. The highest concentration (3%) of novel organic acid (GA) tested in this study yielded no reduction in EC, CO, and APC counts compared with the control. Results suggest that the deleterious effects exhibited by the organic acids and PAA were consistent between both enumeration methods (conventional plating and LITMUS RAPID-B) with one exception. CL treated samples produced lower counts of surviving bacteria with EC and CO compared with RAPID-B. These data suggest that CL negatively affects EC and CO enumeration efficacy. The results of this study indicated that CL, PY, and MA were the most effective antimicrobial treatments in reducing *E. coli* O157:H7 population on beef trimmings and that in most cases the Litmus RAPID-B *E. coli* O157 assay was able to immediately produce results consistent with those determined by plating.

Keywords: Antimicrobial interventions, Peroxyacetic acid, Novel organic acids, *Escherichia coli* O157:H7, Litmus RAPID-B, Ground beef safety

Effects of novel organic acids and ethoxylated glycerol against *Escherichia coli* O157:H7 as antimicrobial interventions for inoculated beef trimmings

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Frequent ground beef product recalls mandates the need to implement more effective decontamination strategies of beef trimmings intended for the production of ground beef. Microbial safety of the ground beef produced from beef trimmings will be advantageous in reducing the incidents of food-borne pathogens and consequent safety recalls. Current decontamination techniques applied during the production chain of ground beef are not yet sufficient, and continues to pose serious concern to the US meat industry and consumers. Ground beef is generally stored and/or displayed at low temperature (2–5 °C). Although, the microbial growth is minimal at this temperature, presence of any foodborne pathogens in ground beef products can challenge product safety. Therefore, the objective of this study was to investigate the antimicrobial efficacy of peroxyacetic and other novel food grade organic acids with or without a non-ionic surfactant (ethoxylated glycerol; EG) on reduction of *E. coli* O157:H7 on beef trimmings. Experiments were conducted to determine the antimicrobial efficacies of peroxyacetic acid (PAA; 200 ppm) and 3% of other novel organic acids [malic acid (MA); levulinic acid (LA); pyruvic acid (PY); caprioc acid (CO), caprylic acid (CL)] with and without non-ionic surfactant (EG) on reduction of *E. coli* O157:H7 on beef trimmings. A model system was developed to mimic a commercial dip treatment by randomly removing 25 g piece of beef trimming. To achieve 10⁵ cfu/g of *E. coli* O157:H7, inoculated beef trimmings were processed with antimicrobial treatments by dipping in 100 mL solution of novel organic acids for 15 s with and without EG (0.5%). Following antimicrobial treatment, beef trim was stomached for 2 min with 225 mL of 0.1% buffered peptone water and spread plated in duplicates on aerobic plate count (APC), and *E. coli* O157:H7 (EC)/coliform (CO) counts of Petrifilm plates using serial 10-fold dilutions scheme. Samples were incubated at 37 °C in an aerobic incubation chamber. Inoculated beef trimming treated with and without water (IN; IN + W) and un-inoculated (UN) samples served as controls. Results suggest that incorporation of a surfactant did not enhance the

antimicrobial efficacies of PAA and other novel organic acids tested in this study. Organic acids and PAA without EG exhibited deleterious effects on survival of EC, CO, and APC. CL without EG reduced more than 5-logs of EC and CO, and 3.38 logs of APC, however, when combined with EG, the same treatment yielded only 1.36, 1.67, and 2.16-logs of reduction of EC, CO, and of APC respectively. Incorporation of EG with other organic acids resulted in no enhancement in microbial reduction. Treatment of beef trimmings with PAA, LA, and CO without EG resulted in no reduction of EC, CO, and APC. The results of this study indicated that CL, PY, and MA were the most effective antimicrobial treatments in reducing *E. coli* O157:H7 population on beef trimmings and incorporation of EG exhibited no enhancement in microbial efficacy.

Keywords: Antimicrobial interventions, Novel organic acids, Non-ionic surfactant, *Escherichia coli* O157:H7, Ground beef safety

The potential for cultured sugar and vinegar to inhibit *Clostridium botulinum* in uncured ham

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Clostridium botulinum poses a health threat in processed meat products due to its ability to form toxins. Suppression of toxin formation has traditionally been achieved by adding nitrite, which has disadvantages due to its perceived health impact. Cultured sugar formulations have been proposed as an alternative inhibitor of toxin production and have also been shown to reduce the growth of spoilage species including *Cl. perfringens*. In the present study the ability of a cultured sugar/vinegar formulation (PuraQ Verdad NV55 – a mixture of organic acids produced by fermentation) to inhibit the growth of clostridia in vacuum-packaged uncured hams prepared from top-side pork and stored at 3 different temperatures was evaluated using a *Cl. sporogenes* model. Hams were prepared from pork topside (80%), water (14.5%), modified corn starch (2%), malto-dextrine (1.5%), sodium chloride (1%), carrageenan (0.7%) and sodium tri-polyphosphate (0.3%). Four levels of added formulation were compared: 2, 3, 4 and 5%. Formulations were added to the brine before addition to the meat. Replicate (2) hams were inoculated with *Cl. sporogenes* at a level of 100 cfu/g before storage. Organisms were added to the shredded meat during preparation in a bowl chopper. After 3 d incubation at 30 °C, PuraQ[®] Verdad NV55 levels ranging between 3% and 5% were associated with reduced *Cl. sporogenes* populations of between 1 and 3 log cfu/g respectively compared with untreated uncured control ham ($P < 0.05$). Reduction was more pronounced at 20 °C incubation with inhibition of growth for up to 50 d in hams treated with 4% or 5% PuraQ Verdad NV55 ($P < 0.05$). No growth occurred at 12 °C. These results indicate that PuraQ Verdad NV55 may be effective for inhibiting the growth of *Cl. botulinum* and production of toxins in stored hams during storage.

Keywords: Food safety, *Clostridium botulinum*, Cultured sugar

Lactic acid spray reduces *Campylobacter* and *Pseudomonas* on hot poultry carcasses

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Lactic acid (LA) sprayed onto meat surfaces can reduce specific microbial populations by meaningful amounts. In a case study, changes

in naturally acquired bacterial populations were examined on sets of 36 commercially processed poultry carcasses sprayed with or without 4% buffered LA solution either before (hot carcasses) or after (cold carcasses) chilling. Carcasses received an average of 19 g/kg spray delivered as 17 s bursts at 122 g/min using an electrostatic spray system previously determined to give even coverage with droplet sizes of 40 μm VMD (Volume Median Diameter). Microbiological testing was performed using standard methods on homogenates prepared from surface samples removed by excision. Statistical interpretation of non-normally distributed data was performed using qualitative analysis of residuals. Differences reported were either strong or very strong. An average of 5 g and 11 g of applied solution was retained per kg carcass weight respectively, with the differences attributed to levels of retention within the cavity. For hot carcasses, LA treatment was associated with an initial 0.27 log reduction in aerobic populations (APC) increasing to 1.25 log after 6 d aerobic storage at 4 °C. *E. coli* and coliform populations were initially undetectable on hot carcasses after treatment but recovered to levels of viability similar to untreated controls after 6 d storage. *Campylobacter* were also initially undetectable on hot carcasses after treatment and after 6 d storage was present at levels lower than those measured on untreated controls. *Campylobacter* were not observed to be eliminated from individual carcasses. *Pseudomonas* were present on hot carcasses at levels similar to untreated controls initially, but were observed to be an average of 0.76 log lower after 6 d storage. Compared with hot carcasses, cold carcass treatments produced lower levels of microbial reduction generally. For example, *Campylobacter* populations were detectable initially and recovery was greater than for hot carcasses after 6 d storage. Similarly, *Pseudomonas* populations were higher after 6 d storage for cold carcasses than for hot carcasses. The results of this study indicate that LA, when used as a surface spray on hot carcasses, can be an effective means of reducing the viability of *Campylobacter* and *Pseudomonas* populations for at least 6 days at 4 °C storage.

Keywords: Food safety, *Campylobacter*, Poultry

Stability of biophotonic *E. coli* O157:H7 and its effectiveness as a validation tool in beef purge sampling methodologies

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Escherichia coli O157:H7 continues to be a concern for the beef industry and has caused numerous recalls and foodborne illnesses in the United States. The objectives of this study were to determine stability and survivability of biophotonic *E. coli* O157:H7 (*BEC*), determine if *BEC* can be an effective real-time tool to validate industry sampling practices, and determine if purge is an effective method to test *E. coli* O157:H7 contamination in beef trim combos. In phase I, 2 separate temperatures (2.2 °C and 37 °C) were used to determine stability and survivability of *BEC*. Cultures of *BEC* ($n = 3$) were placed in a 2.2 °C cooler for 192 h and sampled at 24 h intervals to monitor growth and photonic emission. Concentration of the bacteria remained constant ($P > 0.05$) and photonic emissions (RLU/s) did not change ($P > 0.05$), resulting in a positive correlation between RLU/s and cfu/mL ($P < 0.01$; $r = 0.5718$). Additional cultures of *BEC* ($n = 3$) were placed in a 37 °C forced air orbital shaker and sampled in fresh tryptic soy (TS) broth daily for a 24 h incubation time to determine photonic emissions through 10 d of replication. The *BEC* concentrations did not change during 7 d of replication and sampling ($P > 0.05$); however, cfu/mL increased on d 8–d 10 ($P < 0.05$). In phase II, cylinders (30.48 cm \times 15.24 cm; $n = 2$) were filled with fresh beef trim pieces (5 cm³) and one 5 cm³ piece for each cylinder was inoculated with 5×10^{-7} cfu/mL *E. coli* O157:H7 and placed on top of the trim to determine purge amounts and bacteria migration. Purge was

sampled for 48 h at 4 h intervals in sterile beakers to monitor volume and photonic emissions. Purge quantity decreased ($P < 0.05$) between 0 and 8 h then increased ($P < 0.05$) at 24 h. Purge from cylinder A was found positive for photonic emission at 4 h–32 h. Purge from cylinder B was positive for *BEC* from 4 h–16 h and again at 48 h. Phase III was designed to represent current industry size of trim and test the effectiveness of sampling purge in beef trim combos. Columns (91.44 cm \times 15.24 cm; $n = 8$) were used to simulate height of beef trim combos. Two different beef trim levels (80/20 and 65/35; % lean/% fat) were obtained from a harvest facility <72 h postmortem and columns were filled with 13.57 kg of either 80/20 or 65/35 trim and placed in a cooler (2.2 °C). One piece of trim for each column was inoculated with 4.0×10^{-7} *BEC* ($n = 2$ /trim level) and placed at the top of each (controls – not inoculated). Purge was collected at 4, 8, 12, 16, 20, 24, 36, and 48 h in sterile beakers to monitor purge quantity and photonic emission. Purge was not present at each time point; however, when purge was collected, quantities were small (<200 μL). No photonic emission was found in the purge samples, and no cfus were present when purge was plated on TS agar + kanamycin (30 $\mu\text{g/mL}$). Purge sampling was more effective when collected from smaller pieces (phase II), possibly due to increased surface area and shorter migration distance versus purge sampling in phase III. Purge may have inconsistent quantities in differing beef trim combos and further research should be conducted on sampling methods for purge in beef combos.

Keywords: *E. coli*, Validation, Purge

Inactivation at various temperatures of bovine viral diarrhoea virus in meat derived from persistently infected cattle

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Bovine viral diarrhoea virus (BVDV) is a pathogen that causes gastrointestinal, respiratory and reproductive disease in cattle. Based on available research, BVDV is not considered zoonotic. Our research objective was to evaluate the detectable concentration of BVDV in 4 primal cuts of beef from persistently infected (PI) animals immediately after slaughter, aging, freezing, and cooking to variable temperatures. Six PI beef cattle were humanely harvested. These 6 animals were infected with a genotype 1a ($n = 4$), genotype 1b ($n = 1$) or genotype 2 ($n = 1$) strain of BVDV. Five gram samples cut from the interior of primal cuts (chuck, rib, loin, and round) were removed fresh (Day 0) and after aging for 2, 7, 14, and 21 d. Furthermore, these 4 primal cuts sampled from the interior of a steak and 3 ground products (ground chuck, ground round, and ground beef) sampled as grab samples were prepared from each carcass after 2 d of aging, frozen, thawed and assayed for BVDV raw or after cooking to 55, 60, 65, 70, 75, and 85 °C. All samples of beef were assayed for detection and titration of infectious BVDV using virus isolation after being minced with sterile scissors and subsequently blended in a commercial blender. The concentration of BVDV in beef after aging varied significantly depending on the duration of aging ($P = 0.05$) but not depending on the cut of meat or the animal. The concentration of BVDV in frozen, thawed, uncooked beef varied significantly depending on preparation as a ground product compared with not ground ($P = 0.01$). The average cell culture infective doses [50% endpoint; CCID₅₀]/g of intact meat was $10^{5.85}$ compared with $10^{6.01}$ CCID₅₀/g of ground meat. The cut of meat, preparation as a ground product, or animal did not significantly impact detection of BVDV after cooking to any temperature. Results demonstrate that viable BVDV in beef survives aging, freezing, and thawing. To destroy BVDV in beef cuts, internal temperatures must exceed 70 °C during cooking. This

research demonstrates that BVDV maintains viability within beef from persistently infected animals despite aging for up to 21 d, freezing and thawing, and cooking up to 70 °C as the target temperature. These results are consistent with prior research results involving classical swine fever virus, a related pestivirus of swine. Care should be taken to ensure that susceptible hosts such as pigs are not fed improperly cooked meat, meat by-products or waste food originating from PI cattle.

Keywords: Bovine viral diarrhoea virus, Persistently infected, Virus isolation

Evaluation of electrostatic spray application of antimicrobials in sequential treatment combinations on product safety and instrumental color qualities of beef *Biceps femoris* muscles

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Beef product safety is a serious concern for the meat industry as microbial pathogens can be introduced to muscle surfaces at various sources during processing. Studies have suggested that the use of antimicrobial agents and novel spray techniques as antimicrobials may reduce the microbial load in beef products. Therefore, the objective of this study was to evaluate the effectiveness of antimicrobial sequential treatment combinations on microbiological and instrumental color characteristics of beef *Biceps femoris* muscles treated at the sub-primal level. Beef *Biceps femoris* muscle (n = 12) were cut into 3 subsections (n = 36 total subsections) and were dipped in inoculum containing *Escherichia coli* (EC; ATCC#11775) and *Salmonella* Typhimurium (ST; ATCC#1769NR) at 10⁷ cfu/mL. Each subsection was treated using a commercial electrostatic sprayer (3 mL/sec/60 psi) with either: (1) 20% hydrochloric/citric (CitriLow) acid mixture followed by 0.4% cetylpyridinium chloride (CIT/CPC), (2) 20% hydrochloric/citric acid mixture followed by 3% potassium lactate (CIT/KL), (3) 20% hydrochloric/citric acid mixture followed by 10% trisodium phosphate (CIT/TSP), (4) 0.4% cetylpyridinium chloride followed by 3% potassium lactate (CPC/KL), (5) 0.4% cetylpyridinium chloride followed by 10% trisodium phosphate (CPC/TSP), (6) inoculated untreated control (IN) or (7) uninoculated untreated control (C). Each subsection was cut into 3 individual steaks (n = 108) allowing 15 steaks per treatment per day of display. Steaks were sampled for EC, ST, coliforms (CO), and aerobic plate count (APC) analysis on d 1, 2, 3, 4, and 7 of display. The instrumental color characteristics (CIE L*, a* and b*) were measured using illuminant A/10° observer on the same days and hue angle and saturation index were calculated. All treatments except CPC/TSP treatment significantly reduced (P < 0.05) EC and APC counts compared with INCON. The CIT/CPC and CIT/KL treatments reduced (P < 0.05) EC, CO, and APC counts by up to 2.5 log cfu/g. EC, CO, ST, and APC counts were reduced (P < 0.05) from d 2 through d 4 of display. Furthermore, there was no difference among treatments for L*, a*, or saturation index. On d 1, all treatments had similar (P < 0.05) hue angle when compared with the control. However, on d 7, IN retained the reddest color (P < 0.05); (hue angle) compared with all the treatments. The L* and saturation index remained the same on d 1 through d 4 of display, however a* and b* reduced with display time. Results suggest that treatment of the *Biceps femoris* muscles at the sub-primal level with allotted treatment combinations may enhance shelf-life initially, but become similar to the control by d 7 of display.

Keywords: Antimicrobials, Beef, Hydrochloric/citric acid

Evaluating whether trimming chilled beef during fabrication will control *Escherichia coli* O157:H7

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A current concern for the beef industry is *Escherichia coli* O157:H7 contamination of beef intended for non-intact products. Non-intact products include beef that has been enhanced by vacuum tumbling, mechanically tenderized by cubing, needle injected to incorporate a marinade, or subjected to a comminution process such as grinding, chopping, or mincing. Although all of these processes are not the same, pathogens may be introduced below the surface of these products. Fabrication often involves removing external carcass surfaces, which can be contaminated with *E. coli* O157:H7, to generate closely trimmed subprimals. Therefore, non-pathogenic surrogates for *E. coli* O157:H7 were used to evaluate the effectiveness of trimming external carcass surfaces during fabrication. Carcass sides (n = 10 sides) were inoculated along the hide pattern opening before entering the blast chill cooler with a gelatin slurry containing a bacterial cocktail of 3 rifampicin-resistant, non-pathogenic *E. coli* Biotype I strains (mean concentration of the gelatin slurry following the addition of the cocktail was 7 log₁₀ cfu/ml). Initial inoculum levels on the carcass surface were found to be approximately 2 log₁₀ cfu/ml lower than the concentration of the gelatin slurry before application. Following a 48 h chill, sides were fabricated to produce 8 subprimals: ribeye, brisket, shoulder clod, chuck roll, short loin, top sirloin, inside round, and bottom round. Microbiological samples were taken from the original carcass fat surface area, initial lean surface area, trimmed fat surface area (where applicable), and trimmed lean surface area (where applicable). Similar trends were seen in before and after trimming effects for the lean and fat surfaces of each subprimal. In 6 of the 7 subprimals where there were direct comparisons between before and after trimming for fat, the after trimming fat surfaces had lower (P < 0.05) counts of rif-resistant *E. coli* than did the before trimming surfaces (the bottom round did not respond this way). For the most part, trimming external fat surfaces to produce these closely trimmed subprimals resulted in significantly lower pathogens on the resultant surfaces than if no trimming had occurred. For all 8 subprimals, the before trimming lean surfaces had lower (P < 0.05) counts of rif-resistant *E. coli* than did the before trimming fat surfaces, which further implies that significantly fewer pathogens will be on the initial lean surfaces when these subprimals are prepared than on the outside fat surfaces of the cut. However, in the limited direct comparisons of rif-resistant *E. coli* counts between the before and after trimming comparisons for the lean surfaces, in one subprimal they decreased (brisket), in one they increased (ribeye), and the remainder they did not differ between the 2 lean surfaces. At this point, there are minimal changes in the lean surfaces of subprimals compared with the opportunity to remove fat surfaces. Trimming external surfaces reduced levels of pathogens, but under normal fabrication processes, pathogens were still spread to newly exposed surfaces.

Keywords: Beef, *Escherichia coli* O157:H7, Decontamination

Salmonella, *Campylobacter*, and putative non-O157 shiga toxin-producing *Escherichia coli* (stec) prevalence in ground beef and whole muscle beef cuts at retail in the United States

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Salmonella, *Campylobacter*, and non-O157 shiga toxin-producing *Escherichia coli* (STEC) cause considerable human illnesses each year,

and the vast majority of cases are food borne. Currently, very little is known about the burden of these pathogens in the US beef supply. The purpose of this study was to establish the prevalence of *Campylobacter*, *Salmonella*, and Non-O157 STEC in beef products collected from US retail markets. Sample collection occurred during the months of February through May 2010. Thirty-two American cities comprising 28 states were sampled in this study. Retail raw ground and whole muscle beef (n=2,915) samples were purchased and examined for the presence of *Salmonella*. Samples were enriched in tryptic soy broth (TSB) and incubated for 24 h at 37 °C. *Salmonella* positives were confirmed using the AOAC approved BAX system rtPCR. Of the original samples purchased, 1,211 were randomly selected and tested for *Campylobacter*. Positive samples were confirmed through direct plating and latex agglutination. Samples were enriched using Bolton selective broth and incubated for 48 h at 42 °C. Enriched samples were grown on blood-free *Campylobacter* plates in required microaerophilic conditions. A sub-sample (n=325) was enriched in TSB and glycerol (TSB + glyc) and frozen at -80 °C to be analyzed at a later date. Samples were screened for putative non-O157 STEC using rtPCR methods. *Salmonella* was detected in 0.65% of the total samples purchased. The prevalence for whole muscle cuts was 1.02%, and *Salmonella* was present in 0.54% of ground beef samples. *Campylobacter* was recovered from 9.3% of samples (n=112), with a prevalence of 17.24% in whole muscle cuts and 7.35% in ground beef. Putative non-O157 STEC antigens were detected in 5.9% of samples. Whole muscle cuts had a prevalence of 4.11%, and ground beef sample prevalence was 6.99%. The most common serotypes detected in this study were O26 (3.8%), O145 (2.2%), O103 (1.3%), and O111 (0.98%). A chi-squared analysis was conducted using the FREQ procedure of SAS. A greater percentage of O26 was observed compared with O111 and O103 ($P=0.01$ and $P=0.04$, respectively); however, no other comparisons between putative non-O157 STEC were significant ($P>0.05$). Whole muscle cuts had a higher prevalence of *Campylobacter* compared with ground beef ($P<0.01$); however, comparisons between whole muscle cuts and ground beef for the other 2 pathogens were not significant ($P>0.05$). Creating pathogen baselines in US retail beef is imperative for targeting interventions for pathogen control. These data can be utilized for a more complete understanding of these pathogens and their impact on public health from the consumption of beef products.

Keywords: Putative non-O157 shiga toxin-producing *E. coli*, *Salmonella*, *Campylobacter*

In-plant thermal process validation for whole muscle jerky using SAGA 200 starter culture as pathogen surrogate

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Demonstrating adequate bacterial lethality of unique beef jerky thermal processes is necessary for meeting regulatory requirements but difficult to validate with great concern surrounding introducing pathogens in a plant setting. Use of starter culture as a pathogen surrogate provides an opportunity for processors to validate in-plant thermal processes without concerns of plant or product contamination. This in-plant experiment was conducted to establish the magnitude of bacterial lethality with 2 processor specific thermal processes (traditional processes with limitations on smokehouse humidity). A ≥ 5.0 log reduction must be achieved to approve the processes as appropriately lethal according to regulatory requirements. Two experiments were conducted using 2 different thermal processes. Process 1 - a low temperature thermal cycle with no humidity control. Process 2 - a high initial temperature reduced to low

temperature for the majority of the thermal cycle with no humidity control. Strips of 2 styles of sliced beef top round were inoculated using SAGA 200 starter culture (n=35). Samples (n=5) were collected pre-inoculation, post-inoculation (dwell time 60 min), post-marination, mid-cycle thermal cycle and on finished dried product representing the top, middle and bottom of the cooking rack. Strips were stomached in PWD buffer and were plated on MRS agar to effectively recover lactic acid bacteria and establish bacterial counts. Initial counts on inoculated samples were sufficiently high - in the range of 7.8–7.9 log cfu/g. Total log reduction on jerky strips throughout the thermal processes was found to be <2.5 log cfu/g. These results suggest that further testing needs to be conducted with alternative thermal processes to achieve necessary lethality for regulatory requirements.

Keywords: Jerky, Validation, Surrogate

Effects of lactic acid on *Salmonella* levels on non-federally-inspected whole muscle beef steaks purchased in meat markets of Mexico

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Today in many developing countries, food safety is a major concern. Specifically in Mexico, foodborne illnesses are the leading cause of death in small children. These cases occur due to contaminated products that are not processed under hygienic conditions from lack of information at all processing and consumer levels. Unlike the United States, not all beef slaughter and processing facilities require federal inspection creating an unsanitary, but preventable food production environment. Presently the only reputable inspection in Mexico, in a few facilities across the country, is "Tipo Inspeccion Federal" (TIF). The objective of this study was to evaluate the effectiveness of a 5% lactic acid dip and a 5% potassium lactate dip in whole muscle beef steaks purchased from Mexican retail markets on *Salmonella*. Non-federally inspected whole muscle beef steaks (approximately 100 g) were purchased from city markets, street vendors, and butcher shops across the cities of Cancun, Merida, Veracruz and Mexico City, Mexico. Lactic acid samples were purchased in duplicate to serve as a control and treated in a 5% lactic acid dip solution. Samples were collected during the summer months of 2010 and 2011, from Cancun (n=100), Merida (n=153), and Veracruz (n=268), duplicate included. Potassium lactate duplicate samples were also purchased as control, and treated in a 5% potassium lactate dip solution from cities of Cancun, Merida, Veracruz and Mexico city during fall (n=98, n=96, n=100, n=76, respectively, duplicate included), Winter (n=100, n=100, n=94, n=80, respectively, duplicated included) and Spring (each city n=100, duplicate included). To date, Veracruz has been only been sampled during the Summer (N=100, duplicated included). The presence of *Salmonella* was confirmed by the use of the Dupont Qualicon BAX® system. All data was analyzed with Statistical Analysis System (SAS) 9.1.3 softwares proc FREQ procedure. *Salmonella* prevalence in control samples ranged from 25.37% to 75.32% (Cancun 46.0%; Merida, 75.32%; and Veracruz, 25.37%). However, there was a percent reduction in *Salmonella* after lactic acid had been applied (Cancun, 10.00%; Merida, 71.42%; and Veracruz, 14.92%). Thus far, the control samples for the potassium lactate study has shown an overall prevalence of *Salmonella* (fall, winter and spring seasons) in Cancun, Merida, and Mexico City 44.29%, 60.81% and 5.47%, respectively. The percent *Salmonella* slightly decreased after potassium lactate was applied in samples from Cancun (44.96%), Merida (53.37%), and Mexico City (4.69%). Overall, Veracruz control samples averaged 19.29% for *Salmonella* before the application of potassium lactate, but decreased

12.18% upon potassium lactate treatment. The current study indicates that the application of either lactic acid or potassium lactate dip reduces levels of *Salmonella*. Therefore, implementing a type of lactic acid at a 5% level could reduce food-borne illness' in whole muscle beef cuts from non-inspected beef.

Keywords: Beef food safety, *Salmonella*, Mexico

Influence of lactic acid spray applied in a cold environment and vacuum packaged storage on the presence of *Escherichia coli* O157:H7 on beef strip loins

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This study investigated the survivability of *Escherichia coli* O157:H7 on beef strip loins treated with lactic acid spray (5%; LA) before management under simulated industry conditions. A common method to improve beef palatability is through mechanical tenderization. In addition to improving palatability, mechanical tenderization introduces the risk of translocation of pathogenic bacteria into the interior of beef cuts. Consequently, foodborne illnesses have been associated with the consumption of non-intact beef products. Therefore, reducing the presence of *E. coli* O157:H7 on beef strip loins before mechanical tenderization is imperative. Beef strip loins ($n = 40$) were inoculated with high (10^5 log cfu/cm²) or low (10^3 log cfu/cm²) amounts of *E. coli* O157:H7, treated [5% LA or control (CON)], vacuum packaged, and stored for 21 d (0 to 4 °C). To assess attachment and reduction of *E. coli* O157:H7 due to treatment and storage, microbial samples were taken from subprimals 15 min post-inoculation, approximately 5 min after treatment (LA or CON), and after 21 d of vacuum packaged dark storage. Surface swabs (50 cm²) were enumerated by plating on MacConkeys agar with TSA overlay. Results indicated that *E. coli* O157:H7 levels were reduced ($P < 0.05$) on lean and fat surfaces of high inoculated subprimals immediately after LA application 2.0 and 2.6 log cfu/cm², respectively. *E. coli* O157:H7 levels were also reduced ($P < 0.05$) on lean and fat surfaces of low inoculated subprimals immediately after LA application 1.0 and 0.7 log cfu/cm², respectively. After 21 d of vacuum packaged storage, LA was shown to have no effect ($P > 0.05$) on the total *E. coli* O157:H7 counts on lean surfaces of high inoculated subprimals; however, there was a 1.0 log cfu/cm² reduction ($P < 0.05$) on fat surfaces. While a 0.7 to 2.6 log cfu/cm² reduction ($P > 0.05$) in the presence of *E. coli* O157:H7 was observed on the subprimal surface after 21 d of storage, no LA treatment effect was noted for either the lean or fat surfaces of low inoculated subprimals ($P > 0.05$). These data suggest vacuum packaged storage for 21 d is effective in reducing the presence of *E. coli* O157:H7 on the surface of inoculated beef subprimals.

Keywords: Beef, *E. coli* O157:H7, Storage

Validation of lactic acid and ASC Interventions on the reduction of *Escherichia coli* biotype I, coliforms and total aerobic bacteria on beef carcasses processed at a commercial U.S. slaughter facility

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Based on previously published studies, lactic acid and ASC can reduce *Escherichia coli* O157 and *Salmonella* in beef products. A comparison of the 2 interventions was conducted on carcasses in a

commercial beef processing facility as established by the Code of Federal Regulations [CFR, Title 9, § 417.4 (a) (1)] to verify the validity of these interventions in controlling hazards. The purpose of this project was to validate, on site, the use of lactic acid intervention compared with ASC intervention on chilled beef carcasses. Chilled carcasses were randomly sampled, using aseptic techniques, before/after lactic application (4.2%) and ASC application at 3 time points during the day, for a total of 2 d. A total of 60 samples (30 before and 30 after) per day were collected during the course of the processing day. All sampling was conducted by in-plant laboratory technicians at the facility and used the N60 sampling method. At the end of the processing day, samples were shipped in cold conditions to the Food Microbiology Laboratory at Texas Tech University for microbial analysis. Generic *E. coli*, coliforms and APC were enumerated for each sample. Microbial counts were transformed into log cfu per cm² allowing control and stabilization of statistical variance and fulfillment of the requirements for normality before the analysis. Both lactic acid and ASC interventions resulted in significant ($P < 0.05$) quantifiable reductions in *E. coli* Biotype I, Coliforms and total aerobic plate counts. The total APC reduction for lactic acid was 2.5 log cfu/cm² and 2.87 log cfu/cm² for ASC. Coliform reduction for lactic acid resulted in a 2.23 log cfu/cm² and a 2.71 log cfu/cm² reduction for ASC. The generic *E. coli* reduction for lactic acid was 2.65 log cfu/cm² and 3.46 log cfu/cm² reduction for ASC. Lactic acid and ASC interventions (4.2%) in a commercial processing plant are effective in reducing total microorganisms on beef carcasses as observed in this study. This type of validation is useful for processors to comply with USDA-FSIS regulations and to support HACCP plans and to protect public health.

Keywords: Food safety, Lactic acid, ASC

***Salmonella* and *E. coli* O157:H7 prevalence on beef carcasses in a non-TIF harvest plant in the Cuautla, Mexican**

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Non-TIF (Federal Inspection Type) regulated beef processing plants in Mexico are a major concern for this country and especially its young population, because foodborne illness is the number one cause of death for children ages 1–4. Non-TIF plants provide product to central markets and to vulnerable populations. To determine the prevalence of *Salmonella* and *E. coli* O157:H7 on beef carcasses from a non-TIF processing plant in Cuautla, Mexico. The prevalence of *Salmonella* on carcasses during three areas of the slaughter process) was determined. Swab samples were taken from three areas of the slaughter process hide, Pre-Evisceration and Post-Evisceration. Samples were collected in each of two trips to Mexico. Sterile sponges pre-hydrated with buffered peptone water were used to collect a composite sample from the fore shank and midline area of each animal. Samples were transported to Texas Tech University under cold conditions for microbiological analysis within 2 days after collection. *Salmonella* and *E. coli* O157:H7 presence was confirmed using the Dupont Qualicon BAX system. No *E. coli* O157:H7 was detected in any of the samples. Overall, the *Salmonella* prevalence was 42% positive for all hide samples taken on both occasions. At pre-evisceration, 53% of the carcasses were positive for *Salmonella* in September and 31% positive. Determining the baseline in non-TIF regulated processing plants will contribute to the understanding and to pinpoint locations inside the plant where improvements are needed in both food sanitation, training and dressing procedures, and where to implement interventions thus, helping to improve the quality and safety of meat products sold to Mexican consumers.

Keywords: Food safety, Mexico, *Salmonella*

Tools to respond to the top 10 myths regarding the meat and poultry industry

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Negative news coverage and the popularity of *The Omnivore's Dilemma*, *Fast Food Nation*, and *Food, Inc.* are giving profile to myths about food production that are not based on fact. It is important to understand the degree to which these myths are taking hold among Americans and it is essential to target communications efforts around the myths that are most strongly held. AMI retained Harris Interactive to conduct an on-line survey of 2000 Americans. Respondents were asked to score myths on a scale of 1–100 (1 being least favorable; 100 being most favorable), in terms of the degree to which they agreed or disagreed. “Anti” industry respondents ranked the meat industry below 30. The mean favorability score for the meat industry was 48.7, which was higher than automotive (47.4), pharmaceutical (42.3), banking (40.7) and oil and natural gas (39.5). Those who are pro-industry tend to be male, Republican, conservative, married and meat consumers. Those who are “anti” industry are most likely to be female, liberal, higher educated and on some type of vegetarian/non-meat diet. A majority (63%) say they have not heard anything about the production of meat or poultry in the past 3 mo. However, those who reported hearing something said the coverage was mostly negative (77%). Most adults (78%) know that USDA regulates the meat and poultry industry, but few were confident in their regulatory abilities. Forty-seven percent said there is too little oversight by USDA while 3% said there was just the right amount. Adults are slightly more confident in the safety of meat and poultry today than 25 or 50 years ago, but divided on whether it's safer than 10 years ago. The survey overall showed that Americans, unaided, continue to focus on price quality, and freshness when making purchases. However, when probed, they do express concern about several issues. The top myths were identified: hormone use in meat and poultry production; eating too much red meat can increase heart disease risk; Americans today are eating more meat and poultry than recommended; antibiotic use in livestock production is a concern and use is increasing; most sodium nitrite comes from meat products; inspectors only visit meat and poultry plants occasionally and that lack of federal oversight makes livestock abuse common. A multiple media curriculum was developed based on the identified myths: video messages with scientific experts; Web site that debunks top myths, provides facts, and expert resources; a companion Facebook page “Meat MythCrushers” for a more general audience and to respond to day-to-day issues; youth-oriented Facebook page “The Meat Locker”; print piece to be sent to policymakers, elected officials and key reporters; a pocket guide; print MAT releases; and presentations for use in K-12 and civic and business organizations. It is essential to target communications efforts around the myths that are most strongly held by Americans and to focus on correcting misperceptions and avoid raising issues where there is not strong concern or awareness. We must work hard not just to encourage consumption, but to also give consumers permission to feel confident in meat and poultry when they are consuming it. This can help potential erosion of consumption and help avoid public policy initiatives that are based on lack of education, science, and information.

Keywords: Consumer, Myths, Education

Food defense begins at the farm

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The objective of this research and subsequent training sessions was to promote awareness and educate farmers and food manufac-

turers on the principles of food defense, biosecurity and traceability of agricultural commodities and ingredients used in human food production. Agriculture has been listed as a potential target for terrorism in which the security of our food supply may be breached. Intentional, as well as unintentional, threats and attacks can occur in various ways: biological, physical, radiological, chemical or nuclear. In the muscle foods processing chain, preliminary investigations have indicated there are areas throughout production and processing that are susceptible to potential terrorism. Plant audits and surveys have demonstrated that many muscle foods production farms and processing facilities are vulnerable to undetected entrance by unauthorized personnel. Within processing facilities, storage supply areas for ingredients, chemicals, water and ice were found to have varying degrees of security from none to secure. Additionally, batch records, ingredient lot numbers and product codes for complete traceability of finished product were found to be inadequate. Agriculture and food are global industries, and a successful attack would be felt worldwide. Many of the areas and points of evaluation in a defense plan are often overlooked or taken for granted under normal day to day operations by management and employees, but can be very vulnerable points to food security. Food defense and traceability plans are designed to evaluate all areas of a business and infrastructure including: personnel, ingredients, supplies, transportation, processing, distribution, and product tracking. Means by which a company's food defense can be increased is by incorporating transportation vehicle seals, increased ingredient lot data collection and facility surveillance monitoring. Training has and will continue through seminars, workshops, supplementary materials, and checklists. While many larger and corporate structured enterprises in meat, poultry and aquaculture were found to be more prepared on certain principles, we plan to advance training and knowledge further into their sector of the industry, and facilitate those that are not as prepared.

Through effective food defense training and education, farmers and food manufacturers are able to better assess all vulnerable points to develop a defense plan that is best suited for their operation. Whether problems occur from intentional or unintentional means, farmers and food manufacturers need to be prepared to respond quickly and efficiently to problems that arise. Food defense begins at the farm level and continues through all facets of processing and distribution to the consumer. With proper training and awareness, farmers and others throughout the muscle foods chain are better prepared to continue and even increase the security of our food supply.

Keywords: Food-defense, Biosecurity, Traceability

The Pigsaw Puzzle: An interactive approach to introduce the concept of carcass value in market animals

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Carcass value in market animals is a critical concept because it influences all aspects of food animal production systems from genetics to nutrition to the management practices employed. Although important, the concept of value in market animals can be a difficult one to convey to students that have limited exposure to and understanding of animal agriculture. Many of the students in Animal Science and Food Science programs today come from metropolitan areas and thus have little if any hands-on experience with food animals much less with meat products. Additionally, many of these students have negative connotations about meat because of the misinformation that exists in the media and on the internet. The Pigsaw Puzzle has been used as a means of introducing students in secondary and post-secondary institutions to carcass value, anatomy, muscle form and function, adipose and skeletal

development, as well as meat quality and consumer attributes of meat. The Pigsaw Puzzle consists of a side of pork cut into primals and subprimals that the students reassemble into a side. The level of fabrication dictates the difficulty of the Pigsaw Puzzle and can be varied to meet the knowledge of the audience and the available time. Participation in the Pigsaw Puzzle requires students to get out of their comfort zone and come together as a team to assemble the pork side. The first principle that the students learn is food safety since participants are required to wash their hands and don frocks and hairnets. While students are attiring, time is available to further discuss meat inspection and the food safety principles utilized in the meats industry. Next students begin the process of identifying cuts and orienting them. This provides a good opportunity for the demonstration leader to provide some assistance and to begin building a level of trust with the participants that leads to increased openness and interaction. An intact side of pork or a picture can be used to provide the students with information they can use to achieve success. Once the puzzle is completed, the leader can delve into topics like value differentiation among the primals and subprimals; identification of retail cuts that originate from various cuts; the relationship between biological function and meat tenderness; factors that influence meat quality; diet-health issues associated with meat consumption; and others. Students are also encouraged to ask questions which lead to further discussion. The Pigsaw Puzzle is mobile and generally can be transported in a cooler for demonstrations outside of a climate-controlled environment. Participants have generally shown a greater understanding of carcass value in livestock following completion of the Pigsaw Puzzle. Newly acquired knowledge can be assessed by pre- and post-questionnaires, which may include the use of electronic teaching devices like clickers. Overall, the Pigsaw Puzzle has been utilized at the University of Georgia to introduce students with varying levels of agricultural knowledge to the principle of carcass value and to increase their knowledge and interest in meat science through a hands-on, interactive demonstration.

Keywords: Teaching, Carcass value, Pork

Advocating agriculture through the BBQ Boot Camp model

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A large portion of the US population is over 3 generations removed from agriculture. The BBQ Boot Camp program was designed to educate consumers about agriculture production and sustainability, while teaching outdoor cooking methods with meat as the main focus. The BBQ Boot Camp program provides consumers with the opportunity to ask questions about where their food comes from. The format of the program is to provide consumers knowledge based on science. Through the BBQ Boot Camp model, consumer knowledge was analyzed using a pre- and post-program test then a second post-test submitted 3 or 6 mo later. The test questions focused on cooking, agriculture practices, and food safety issues. The tests allowed us to establish a consumer base of knowledge to determine the information needs meat-consuming North Dakotans. Data was collected from 17 cities across the state of North Dakota in the summer of 2009 and 2010 (n=1585 total number observations). Data were analyzed using PROC GLM and PROC MEANS with main effects of City, Sex, and Age and interactions of City*Age, City*Sex, and Age*Sex. Consumer demographics included male and female respondents in 5 different age groups. Male consumers ages 18–29 (n=89), 30–39 (n=130), 40–49 (n=156), 50–59 (n=262) and >60 (n=206). Then female consumers ages 18–29 (n=65), 30–39 (n=76), 40–49 (n=156), 50–59 (n=239), and >60 (n=127).

Through the data we were able to see influential factors affecting consumer purchasing decisions. When asked which factors are more important when making food purchasing decisions 63% of males and 79% of females said price was most important, 83% being young consumers between 18 and 29 years of age. Food safety was also a key factor in consumer purchasing decisions according to males and females with a majority of the concern coming from correspondents >60 years of age at 56%. Program attendees were also asked how often they use a thermometer during cooking, only 10.8% across all age groups and sex responded in the pre-test with that they use a thermometer every time. These percentages increase 9 fold after conclusion of the program to 90.8%, respectively. Consumers were also asked to rate on a 5 point scale, (1 = not useful at all; 5 = very useful) the usefulness of tools educators can use to communicate with them about food production. Out of the five categories (mass media, web site information, personal communication, social networking, and in-person events at a local level) consumers ranked in-person communication as the most important form of communication with an average score of 4.3 out of 5 across sex and all ages. In-person communication increased linearly from younger respondents to older. Respondents choose mass media as the second most important form of communication with an average ranking of 3.56 out of 5. It is important to note that this data only represents people from the state of North Dakota and surrounding areas. Although small when considering the population of the United States, the information that has been collected has shown there are areas of food communication that need improvement.

Keywords: Consumer, Barbeque, Education

Biochemical characterization of white-tailed deer myoglobin

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Game meats are gaining increased consumer acceptance due to low-fat and low-cholesterol contents. White-tailed deer (*Odocoileus virginianus*) is a major game meat species in North America. Although the primary structure of myoglobin (Mb) from several meat-producing mammals has been characterized, the amino acid sequence of white-tailed deer Mb is yet to be determined. Therefore, our objective was to determine the primary structure of white-tailed deer Mb. White-tailed deer Mb was isolated from cardiac muscles utilizing ammonium sulfate precipitation and gel-filtration chromatography. Purified white-tailed deer Mb was subjected to automated Edman degradation, which revealed the identity of 50 residues from the amino terminus. In comparison with the first 5 amino acids of other well-characterized ruminant myoglobins, white-tailed deer Mb shared 100% homology with red deer, beef, and sheep, whereas it demonstrated 98% similarity with goat and water-buffalo.

Keywords: White-tailed deer, Primary structure, Myoglobin

Effects of feeding a single or sequence of β -adrenergic agonists to cull cows on meat quality and muscle biochemical properties

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The objectives of this study were to explore the effects of feeding cull cows a single or sequence of β -adrenergic agonists (β -AA) on meat quality and muscle biochemical properties. Sixty cull cows were implanted with Revalor-200 and assigned to 1 of 4 treatments: C = fed

a concentrate ration; RH = supplemented with ractopamine-HCl (RH) for 25 d before harvest; ZH = supplemented with zilpaterol-HCl (ZH) for 20 d before a 3 d withdrawal before harvest; RH + ZH = supplemented with RH for 25 d followed by ZH for 20 d before a 3 d withdrawal before harvest. All cows were fed a concentrate ration for 74 d. There were 3 replicate pens with 5 cows per pen for each treatment. *Longissimus* muscle (LM) biopsies were collected on d 24, 51, and at harvest from a subsample of 3 cows per pen. Steaks from the 6–7–8th rib section of the LM were used for desmin, collagen, and Warner Bratzler shear force (WBSF) measurements. The 12th rib section of the LM was enhanced with a 0.1 M calcium lactate solution at 7 d postmortem, aged for an additional 7 d, and evaluated for WBSF and sensory traits. *Psoas major* steaks were evaluated for WBSF and sensory traits, and *infraspinatus* steaks were evaluated for WBSF. The remainder of the shoulder clod was fine ground, packaged in PVC overwrap, and used for shelf life evaluation. Few differences existed among treatments for carcass traits; however, ZH supplementation increased LM area. The abundance of β_2 -adrenergic receptor mRNA statistically increased ($P < 0.05$) in the last 23 d of feeding for the RH treatment and numerically increased ($P > 0.05$) for ZH cows. For all cows, abundance of Type IIa myosin heavy chain (MHC) mRNA decreased ($P < 0.05$) after 24 d of feeding, and abundance of MHC-IIx mRNA increased ($P < 0.05$) for ZH and RH + ZH treatments the last 23 d of feeding. *Psoas major* steaks from the RH + ZH treatment were rated as more tender ($P < 0.05$) than steaks from all other treatments. *Infraspinatus* steaks from cows supplemented with β -AA had more tender ($P < 0.05$) WBSF values than controls. *Longissimus* samples from ZH supplemented cows had higher ($P < 0.05$) WBSF values (were tougher) and less ($P < 0.0001$) degraded desmin at 10 and 21 d postmortem compared with RH and C treatments. Percentage of soluble collagen was increased ($P < 0.05$) by ZH supplementation. Enhancement of the LM with a 0.1 M calcium lactate solution alleviated differences in WBSF values among β -AA supplemented and control cows. No differences were observed in ground beef color stability among treatments. Even though there were few differences in carcass characteristics, muscle biochemical data indicated that β -AA elicited a cellular response. Effects of β -AA on sensory characteristics were muscle-specific with positive effects on the *psoas major* and *infraspinatus* muscles and negative effects on the LM. However, LM toughness from β -AA supplementation can be alleviated by calcium lactate enhancement.

Keywords: Cull cows, β -adrenergic agonists, Meat quality

Lipid oxidation-induced oxidation in ratite myoglobins

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Emu and ostrich are ratites gaining increasing popularity as sources of low-fat meats. Lipid oxidation generates reactive secondary products such as 4-hydroxynonenal (HNE), which compromises myoglobin redox stability and meat color. Although previous research characterized the molecular basis of lipid oxidation-induced oxidation in livestock myoglobins, the effect of lipid oxidation on ratite myoglobins has not been investigated. Therefore, the objective of this study was to evaluate lipid oxidation-induced oxidation in ratite myoglobins, in comparison with beef myoglobin, using HNE as the model aldehyde. Emu, ostrich, and beef myoglobins were purified, and oxymyoglobins were prepared and incubated with HNE (0.15 mM myoglobin + 1.0 mM HNE) at pH 7.4 and 37 °C for 6 h (physiological condition). Controls consisted of oxymyoglobin plus a volume of ethanol used to deliver HNE. Absorbance spectra was recorded every 1 h, and percentage metmyoglobin formation was calculated. Percentage metmyoglobin formation increased ($P < 0.05$) over time in all

the 3 species, and HNE accelerated ($P < 0.05$) oxidation of emu, ostrich, and beef oxymyoglobins. HNE-induced metmyoglobin formation was greater ($P < 0.05$) in ostrich oxymyoglobin than in emu and beef oxymyoglobins indicating that lipid oxidation is more critical to meat color of ostrich meat than to beef and emu meat.

Keywords: Ratites, Myoglobin, Lipid oxidation

Effects of 4-hydroxy-2-nonenal on ultrastructure and function of beef mitochondria

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Meat color is an important quality attribute that influences purchasing decisions. Discoloration results in an annual loss of \$2 billion to the meat industry every year. Nevertheless, meat has inherent mechanisms that delay discoloration, including mitochondrial-mediated processes. More specifically, electron transport mediated metmyoglobin reduction (due to oxygen consumption) and reductase present in the outer membrane of mitochondria can limit discoloration associated with metmyoglobin. Approximately 50% of the mitochondrial membrane is unsaturated fatty acids, which can generate reactive secondary lipid oxidation products, including 4-hydroxy-2-nonenal (HNE). Although mitochondria have a major role in color stability through the regeneration of NADH and oxygen consumption, no research has assessed the effects of HNE on beef mitochondrial structure, function, and electron-transport mediated metmyoglobin reduction. The objectives were to assess the role of 4-hydroxy-2-nonenal in (1) mitochondrial oxygen consumption; (2) mitochondrial ultrastructure, and (3) mitochondria-mediated metmyoglobin reduction in vitro at pH 5.6 and 25 °C. Mitochondria and myoglobin were isolated from fresh bovine hearts ($n = 5$) using differential centrifugation and gel filtration, respectively. Mitochondrial protein content was determined using the BCA assay. Oxygen consumption was assessed using a Clark electrode after the addition of succinate (8 mM) to mitochondria (2 mg/ml) pre-incubated with HNE (0.20 mM). Control samples received succinate after mitochondria were pre-incubated with ethanol at a volume equivalent to that used for delivering HNE. For assessing mitochondria-mediated metmyoglobin reduction, isolated mitochondria (2 mg/ml) and metmyoglobin (0.15 mM) were reacted with either succinate (8 mM) and HNE (0.20 mM) or succinate without HNE for 3 h. At specific time points, samples were removed, centrifuged, and the resulting supernatant was used to measure metmyoglobin reduction. Metmyoglobin reductase activity was determined using the change in absorbance at 580 nm after addition of NADH (cofactor). Ultrastructural changes in isolated mitochondria were assessed using transmission electron microscopy. Image analysis was used to quantify the area of mitochondria and to characterize mitochondrial changes in the electron microscopic study. HNE binding to mitochondrial membranes was estimated using fluorescent studies. HNE decreased ($P < 0.05$) oxygen consumption compared with control samples without HNE. In addition, HNE decreased metmyoglobin reduction and reductase activity compared with control mitochondria without HNE ($P < 0.05$). Image analysis showed decreased mitochondrial area, indicating that HNE influenced the ultrastructure of mitochondria compared with control samples. Binding studies in the current study suggest that HNE can bind with the mitochondrial membrane ($P < 0.05$). The results from the current study suggest that HNE decreased the ability of mitochondria to consume oxygen and reduce metmyoglobin, both of which can alter postmortem meat color stability. The effect of HNE on meat color can be attributed to its

reactivity with proteins. Therefore, in addition to covalent binding between HNE and myoglobin, secondary lipid oxidation products may influence color stability by interacting with mitochondria.

Keywords: Metmyoglobin, Mitochondria, Lipid oxidation

Effects of supplemented high linoleic or linolenic oil in the diet on lipogenic enzyme gene expression in subcutaneous adipose tissue of sheep

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A feeding and in vitro trial with 20 sheep (60±6 kg) was conducted to investigate the effects of high linoleic (C_{18:2} n-6; corn oil) or α-linolenic oil (C_{18:3} n-3, perilla oil) with/without sodium bicarbonate on lipogenic enzyme gene expression in 2-h incubated (with/without 100 μM of fatty acid mixture, stearic acid:oleic acid:linoleic acid = 1:1:1) subcutaneous adipose tissue of sheep. All the sheep were fed the diets consisting of roughage:concentrate ratio of 40:60 (DM basis). Corn oil or perilla oil was added to the concentrate at 7% of the total diet (DM basis) before feeding. Chopped alfalfa hay was fed as roughage. Sheep were fed the mixed diets twice (0800 and 1800 h) each day in an equal amount for 3 mo. Feeding 1.2 kg of diets (DM) closely met the daily maintenance requirement of sheep (NRC, 1985). We measured glucose-6-phosphate dehydrogenase (GPDH), acetyl-CoA carboxylase (ACC), fatty acid synthase (FAS), lipoprotein lipase (LPL) and stearoyl CoA desaturase (SCD) gene expression from incubated subcutaneous adipose tissue of sheep. High C_{18:3} in feed caused less ACC and FAS gene expression than high C_{18:2} in diets ($P<0.0001$). Fatty acid mixture in media depressed ACC ($P<0.0001$), FAS ($P<0.0001$) and SCD ($P=0.05$) gene expression in incubated subcutaneous adipose tissues. The fatty acid mixture in ACC and FAS of corn oil-fed sheep than in perilla oil fed sheep ($P<0.05$). We predict that over time, fatty acids from diet would depress lipogenesis.

Keywords: Linoleic acid, Linolenic acid, Lipogenic enzyme

Tocopherol concentrations in erythrocytes from turkeys and ducks and relative ability of the different avian erythrocytes to stimulate lipid oxidation

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Lipid oxidation is a major cause of quality deterioration in muscle foods. Breast and thigh muscle from turkey is more prone to lipid oxidation compared with the respective muscles in duck. A decrease in oxidative stability in turkey muscle may be partly due to lower levels of tocopherol isomers in erythrocytes of turkeys compared with ducks. A low level of tocopherol should weakly protect the erythrocyte membrane from free-radical-mediated lipid oxidation. Free-radical-mediated lipid oxidation leads to release of hemoglobin oxidant from the erythrocyte. Hemoglobin content was reported to be greater than myoglobin content in breast and thigh muscle from broilers, which indicates substantial levels of erythrocytes in poultry muscle after slaughter. One objective of this work was to determine α and gamma isomer levels in turkey and duck erythrocytes. A second objective was to assess the ability of turkey and duck erythrocytes to

promote lipid oxidation in washed muscle fibers. Blood was obtained from fasted ducks and turkey at market weights from commercial producers. Erythrocytes were prepared from whole blood by removing plasma and then washing the packed erythrocytes 3 times in 9 vol of 1 mM Tris (pH 8) containing 1.7% NaCl. Lipid was extracted from erythrocytes using a mixture of chloroform/methanol or initially homogenizing in methanol followed by addition of chloroform. Tocopherol isomers were determined using HPLC with fluorescence detection. Intact erythrocytes were added to washed turkey muscle (pH 5.6) using a hemoglobin concentration of 10 μmol/kg washed muscle. Lipid peroxides, TBARS and hexanal were used as indicators of lipid oxidation during up to 8 d of iced storage. Loss of redness was also followed during storage. Homogenizing erythrocytes initially in methanol and then adding chloroform produced better lipid extraction compared with homogenizing in a mixture of chloroform/methanol. Alpha tocopherol was significantly higher in ducks erythrocytes ($P<0.05$) compared with turkey erythrocytes (9.3 ± 3.2 compared with 1.3 ± 0.7 μmol/ml packed erythrocytes). Gamma isomer levels were on average higher in the turkey erythrocytes (23.8 ± 13.3 compared with 16.2 ± 11.7 μmol/ml packed erythrocytes). Inducing hemolysis by osmotic shock accelerated erythrocyte-mediated lipid oxidation in washed muscle. In trial 1, intact duck erythrocytes promoted lipid oxidation in washed muscle significantly faster compared with intact turkey erythrocytes. However, EDTA anticoagulant was used for ducks and heparin anticoagulant in turkeys. The ability of EDTA to facilitate hemolysis in avian species has been reported. In trial 2, heparin was used in the collection of both duck and turkey blood. In trial 2, intact duck erythrocytes promoted lipid oxidation slightly but significantly faster than turkey erythrocytes. The similar ability of turkey and duck erythrocytes (in a common anticoagulant) to promote lipid oxidation may be explained by similar additive amounts of vitamin E isomers in both types of erythrocytes even though α tocopherol was 7-fold greater in duck erythrocytes. Thus, the high susceptibility of turkey muscle to lipid oxidation appeared associated with factors other than particularly labile erythrocytes.

Keywords: Vitamin E, Meat quality, Hemolysis

Effects of maternal nutrition on hind limb composition of bovine fetuses

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Inadequate nutrition is often encountered by gestating cows due to decreased forage quantity and quality resulting from environmental conditions. Maternal nutrition during mid-gestation influences adipose tissue and skeletal muscle development in many species, yet research is limited in beef cattle. Therefore, the objective of this research was to determine the influence of maternal nutrition on bone, muscle, and adipose tissue development in bovine fetuses at 180 d of gestation. Twenty-two Angus crossbred heifers of similar genetic background were artificially inseminated to the same Angus bull. Heifers were randomly allotted into 3 different dietary treatments from d 85 to 180 of gestation. The dietary treatments provided 180% (HIGH; n=7), 107% (INT; n=7), and 88% (LOW; n=8) of maintenance energy requirements for growing pregnant heifers. At d 180 of gestation, fetuses were removed by cesarean section and the *semitendinosus* (ST) muscle of the left hind leg was dissected. Samples were fixed in paraformaldehyde and stored in ethanol for determination of muscle fiber cross-sectional area and diameter. Fixed samples were embedded in paraffin and transverse sections, 10 μm thick, were cut and stained with hematoxylin and

eosin. A minimum of 300 muscle fibers were analyzed for each fetus to determine fiber area and diameter. The entire right hind limb was removed from each fetus above the hip joint, weighed, and frozen at -20°C for analysis of intramuscular fat content of the ST and bone weight. Upon thawing, the ST was dissected from the hind limb along with the femur bone. Intramuscular fat content of the ST was determined using ether extract. All muscle tissue was removed from the femur, and the bone was boiled for 2.5 h in water. The proximal and distal epiphyses were removed, and bones were air-dried for 7 d, followed by oven drying for 72 h at 70°C . Following the drying protocol, bone length and weight were determined. Histological analysis of fiber cross-sectional area and diameter revealed no differences ($P=0.64$ and 0.56 respectively) between treatment groups indicating maternal nutritional status did not influence muscle development in the ST. Additionally, no differences were detected for femur length, femur weight or crude fat percentage of the ST ($P=0.81$, 0.98 and 0.44 respectively). These results indicate that fetal hind limb composition at 180 d of gestation is not influenced by the degree of maternal nutrient manipulation imposed in this study.

Keywords: Beef, Fetal programming, Composition

Myostatin gene mutations C313Y and Q204X and how they affect beef quality in crossbred heifers

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The objective of this study was to examine the effects of 2 myostatin gene mutations, C313Y and Q204X with C313Y, on beef quality. One hundred twenty-six crossbred (Angus \times Piedmontese) heifers were weighed, randomly allotted to 1 of 16 pens, and fed for approximately 120 d on corn-based total mixed rations containing either no field pea, dry-rolled field pea included at 15% of diet DM, pea hulls fed at an equivalent portion to 15% whole peas in the ration, or pea chips fed at the equivalent portion to 15% whole peas in the ration. Heifers were fed in 16 identical pens with 4 pens (replicates) in each treatment. Feed intake was recorded daily, and heifers were weighed individually every 28 d to monitor performance during the feeding

period. During finishing, samples were taken from the ear of each heifer and a genetic profile was determined by IGENITY. Due to crossbreeding, heifers were also evaluated for mutations in the myostatin gene, referred to as MUT0 (having no mutation), MUT1 (having a C313Y mutation, and MUT2 (having both C313Y and Q204X mutations). When heifers reached 14 to 16 mo of age (580 ± 43 kg), they were transported to a commercial slaughter facility. The *longissimus thoracis* (LT), *semimembranosus* (IR), *biceps femoris* (BR), and *supraspinatus* (MT) were sampled, vacuum sealed, and aged for 14 d at 4°C . Carcass data were collected after a 48-h chill. Traits analyzed were live weight; hot carcass weight (HCW); 12th rib fat depth (BF); rib-eye area (REA); estimated kidney, pelvic, and heart fat (KPH); USDA yield grade (YG); and marbling score (MARB). Minolta colorimeter measurements were taken and meat tenderness was measured as Warner-Bratzler shear force (WBSF) at 14 d post-mortem. Data was analyzed using Proc Mixed in SAS with block and slaughter date in the model. Diet proved not significant and was removed from the model. The presence of the myostatin gene mutations had no effect on HCW or MARB. BF was significantly lower ($P=0.03$) in heifers with MUT1 and MUT2 compared with MUT0. REA was significantly higher in those inheriting either MUT1 or MUT2 compared with MUT0 (94.06 ± 1.95 cm² and 92.83 ± 1.88 cm² vs. 77.67 ± 4.72 cm², respectively). MUT0 heifers had significantly higher KPH ($P<0.01$) compared with those inheriting either mutation. Both MUT1 and MUT2 had significantly higher ($P<0.001$) YG than MUT0 (2.63 ± 0.12 and 2.72 ± 0.12 vs. 3.93 ± 0.28 , respectively). LT from MUT1 heifers were more tender ($P=0.02$), as measured by WBSF, than those from either MUT2 or MUT0. The LT of MUT1 heifers tended to have a higher a^* (27.22 ± 0.32 vs. 26.15 ± 0.30) compared with MUT2 ($P<0.06$). LT from heifers inheriting MUT2 had significantly lower b^* (7.18 ± 0.23 vs. 8.04 ± 0.25) compared with those from MUT1 ($P=0.04$). The L^* value of the IR was significantly lower (37.43 ± 0.27 vs. 39.04 ± 0.71) than that of MUT0 ($P<0.03$). Our data suggest that the presence of MUT1 and MUT2 in heifers results in changes in Minolta color score values, WBSF, and several carcass traits when compared with MUT0. This study indicates a relationship between myostatin gene mutations (C313Y and C313Y with Q204X) and beef quality.

Keywords: Myostatin, Mutation, Beef quality
